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BULLETIN OF THE TORREY BOTANICAL CLUB

VOL. 84, NO. 3, PP. 151–156 MAY, 1957

FLORAL MORPHOLOGY IN ASIMINA TRILOBA DUNAL[1]

I. DEVELOPMENT OF OVULE AND EMBRYO SAC

ROBERT K. LAMPTON

While working with cultures of the endosperm of the North American Pawpaw, *Asimina triloba* Dunal in vitro, the author encountered some probems which made it necessary to have a full account of the normal ovular morphology of this plant. Such an account could not be found in the existing literature and the present paper is the result of this study.

Flowers and young fruits of the pawpaw were collected from trees growing wild in the vicinity of Ann Arbor, Michigan, near Hillsdale, Michigan and from one tree which had been transplanted years before into the court of the Natural Science Building of the University of Michigan. Normally flowering material was collected in April and May but in several cases dormant buds were collected in January and February, brought into the laboratory and there forced into bloom.

Material for sectioning was fixed in Randolph's modification of Navaschin's fluid, dehydrated through a tertiary butyl alcohol series, imbedded in paraffin and sectioned at 12 microns.

At the beginning some slides were stained in haemotoxylin but it was found that safranin-fast green stain combination gave excellent results and this staining method was used during most of the study.

Flower buds of *Asimina triloba*, produced in late summer and autumn on young stems of the current year's growth, pass the winter in a relatively undifferentiated condition. Stamens and carpels are recognizable in these buds but no spore mother cells become apparent until spring when the weather has become favorable for development of the blossoms.

There are seven to ten carpels in each flower, subtended by a globular mass of many stamens. The carpels are simple, uniloculate, and have a short style topped by an unbranched club shaped stigma. Placentation is parietal with two placentae representing the edges of the carpellary leaf at the line of fusion. Ovules are borne in a single row with alternate ovules inserted on opposite placentae.

The ovule primordium grows rapidly to form an elongated mass of cells with a slight curve toward the outside. A rounded body then develops from the outer side of the mass to form the nucellar protuberance which gives rise to the nucellus and integuments (fig. 2).

[1] This paper represents part of a doctoral dissertation presented to the Horace H. Rackham School of Graduate Studies of the University of Michigan. The author acknowledges his indebtedness to the late Prof. Carl D. LaRue for his interest and encouragement during the investigation.

[THE BULLETIN for March–April, 1957 (84: 69–150) was issued May 20, 1957.]

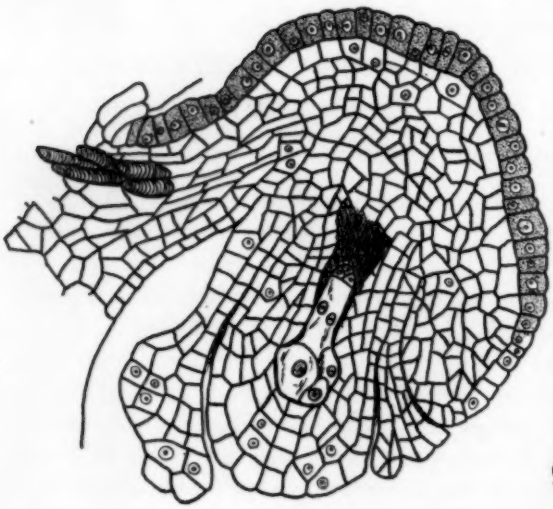
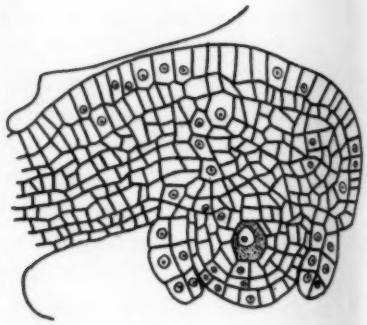


FIG. 1.



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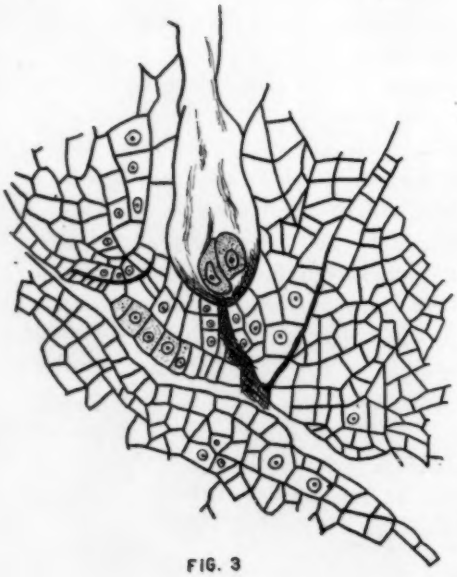

FIG. 3

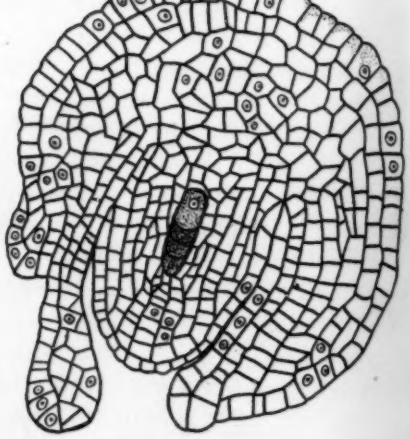

FIG. 4

The cells of the outer layer of the nucellar protuberance are rectangular in outline and form a well differentiated epidermis which is continuous with that covering the whole of the ovule. Immediately beneath the epidermis the cells are oriented into a second layer or hypodermis. The remainder of the cells are angular in outline but have no special arrangement.

When the nucellar primordium has reached a height of from four to six cells above the funiculus one cell situated near the center of the mass and immediately below the hypodermis begins to grow larger than its neighboring cells. This megaspore mother cell increases in size, becomes angular in outline and elongated from base to apex of the nucellus.

The differentiated megaspore mother cell becomes surrounded by about four layers of cells on all sides except for the massive funicular tissue at the chalazal end and by a series of two divisions produces a row of four megaspores (fig. 4). The basal or chalazal megaspore is the functional one and as it proceeds with its development into an embryo sac the other three megaspores degenerate and disappear.

The functional megaspore produces an embryo sac of the monosporic, eight nucleate "Polygonum" type formed from three successive divisions of the megaspore nucleus. The eight nuclei thus produced group themselves to form three cells at the chalazal end of the embryo sac, two wedge shaped synergids and an egg cell at the micropylar end of the sac and the remaining two polar nuclei finally unite to form the secondary nucleus near the middle of the sac (fig. 1).

The antipodal cells are formed early and are ephemeral. They disintegrate rapidly and usually have become very faint in staining reaction by the time fertilization has taken place.

The polar nuclei may lie side by side for some time before fusing to produce the secondary nucleus. The synergid cells fill the micropylar end of the embryo sac and the egg cell lies between and posterior to them.

The complete embryo sac is vacuolate and contains particles of reserve material which is not starch but has a deep staining reaction with safranin.

Development of the integuments.—The integuments appear at the time the megaspore mother cell is differentiated. At the base of the nucellar protuberance a ring of epidermal cells undergoes division and the new cell walls are laid down anticlinally. By continued cell divisions a ring of cells is raised around the nucellar protuberance (fig. 2).

FIG. 1. Section of ovule of *Asimina triloba* showing complete eight nucleate embryo sac, nucellus, integuments and funiculus. × 325. FIG. 2. Section of young ovule of *Asimina triloba* showing megaspore mother cell, massive funiculus and nuclear protuberance with growing integuments. × 325. FIG. 3. Section through part of micropyle and nucellar cap cells of fertilized ovule of *Asimina triloba* showing remnants of pollen tube and two celled embryo at the end of the embryo sac. × 325. FIG. 4. Section through a young ovule of *Asimina triloba* showing a row of four megaspores. × 325.

The nucellus and incipient integument originally grow out at right angles from the funiculus but the end of the funicular mass of cells beyond the protuberance soon bends downward, increases in length, but does not quite maintain the same rate of growth as the inner integument as it grows to cover the nucellus. Growth at the distal end and corresponding downward growth of the edges of the funiculus produce the outer integument of the ovule (fig. 1).

The main axis of the funiculus becomes the raphe and antiraphe within which the vascular hoop of the seed arises. The seed later becomes flattened perpendicularly to this area.

By the time the embryo sac has its normal complement of nuclei the integuments have completely covered the nucellus, the anatropous condition of the ovule has been achieved and the micropyle is adjacent to the short stalk of the ovule (fig. 1).

The outer integument consists of eight to ten layers of cells which completely cover the ovule except for a wide opening at the micropyle through which the inner integument projects. The inner integument is only two layers of cells thick except where it projects through this wide exostome and then it flares out into a thick mass of cells which surrounds the endostome. This is the micropyle. The integuments and nucellus are free from one another except in the region of the vascular hoop. This region is one which remains meristematic and, by cell divisions, adds more elements to all tissues in the ovule as it grows following fertilization (fig. 3).

The vascular system of the ovule up to the time of fertilization is little differentiated from other elements but as development proceeds the cells in the midline of the stalk of the ovule become longer and narrower, thickenings are formed in their walls and they become differentiated into tracheal elements (fig. 1) This differentiation begins with those cells lying in contact with the vascular cells of the placenta and differentiation proceeds upward until a row of tracheal elements in the funiculus extends from the vascular tissue of the placenta up to and beyond the base of the nucellus in the ovule.

The vascular system of the ovule thus differentiated does not enter the nucellus or terminate near the base of the nucellus but continues beyond the chalazal end of the ovule and young seed to form a continuous hoop of vascular elements in the ovule. Corner (1949) has suggested the term "perichalazal" to describe this condition of the vascular system in the seeds of the Annonaceae.

A prominent feature of the nucellus with the mature embryo sac is the hypostase (fig. 1). In *Asimina triloba* the hypostase consists of a mass of cells with thickened walls surrounding the embryo sac at the chalazal end of the ovule. These lignified walls form a deep cup around the lower end of the embryo sac. The embryo sac confined within the hypostase and nucel-

lar cap cells has a bottle shape with the narrow neck at the chalazal end of the ovule.

Discussion. In the heretofore published accounts of the development of the ovule and embryo sac in various species of Annonaceae there is a difference of opinion on the location of the primary archesporial cell in the tissue of the nucellus.

Herms (1907) studied the embryology of *Asimina triloba* Dunal and relied mainly on the figures accompanying the sketchy text to provide necessary information relative to the development of the embryo sac. His statement that the archesporial cell of *Asimina triloba* is hypodermal and divides to form a parietal cell and a sporocyte cell has not been corroborated by the present author. In all cases where it has been possible to pick out one cell at an early stage in its differentiation these cells have been under at least three layers of cells (fig. 2).

In the words of Maheshwari (1950), an archesporium is "one cell of the nucellus (which) becomes more conspicuous than the others owing to its larger size, denser cytoplasm, and more prominent nucleus."

In accord with this definition and the observed material accumulated in the course of this investigation, the primary archesporial cell of *Asimina triloba* is subhypodermal and functions directly as the megaspore mother cell without dividing to give rise to a parietal cell and a primary sporogenous cell. Other than this the development of the embryo sac follows the normal "Polygonum" type of development as in other plants which have monosporic eight-nucleate type of embryo sac development.

Oes (1914) provided a study of the development of the embryo sac and pollen grains in *Cananga odorata*. He found the archesporium in this species to be formed not hypodermally but under three or four layers of cells beneath the nucellar epidermis. He also found no parietal cell formed from a division of the primary archesporium.

Schnarf (1931) compiled information from the published works of Herms, Lecomte, Nicolosi-Roncati, Oes, Samuelsson, Voigt, and from the unpublished work of Leopoldine Stark into a summary of the characteristics of the family Annonaceae and takes exception to the work of Oes. In this "Vergleichende Embryologie der Angiospermen" Schnarf draws some general conclusions and considers the Annonaceae to be characterized by having a hypodermal archesporial cell which divides to form a parietal cell and a sporogenous cell.

Juliano (1935) working with *Annona squamosa* and *Annona muricata* found a condition similar to that reported by Oes in *Cananga odorata* and he took exception to the generalized statements of Schnarf.

The findings reported in this paper agree with those of Oes and Juliano.

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East Orange, New Jersey

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BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 84, NO. 3, PP. 157–162 MAY, 1957

ELYONURUS ARGENTEUS, A SOUTH AFRICAN GRASS WITH FIVE CHROMOSOME PAIRS

ROBERT P. CELARIER

In the Gramineae there is found an extremely high frequency of polyploidy but in only a few instances are the basic diploid numbers encountered (Darlington and Wylie 1955). Species with a haploid number of seven are frequently found but numbers lower than this are extremely rare. Although six and five have been known for some time (Avdulov 1928, Church 1929) it is only within the past ten years that species with four pairs of chromosomes have been reported (Litardiere 1948, 1949).

It has been suggested that five may be the basic number for the entire family (Flovik 1938) and especially for the tribe Andropogoneae (Celarier 1956a). Consequently species with this number are of special interest, particularly in view of the conclusion of Litardiere (1948) that the $n = 4$ types were probably derived from $n = 5$.

In the grasses there are four known genera (*Anthoxanthum, Briza, Coix* and *Sorghum*) that have species with the haploid number of five, and to this we now add the genus *Elyonurus* Humb. and Bonpl. This is the second genus for the tribe Andropogoneae with this number.

The genus *Elyonurus* is a member of the Rottboelliinae section of the subtribe Rottboellieae, and appears to be one of the least specialized members of the section with paired spikelets, and with pedicels that are not fused to the internodes. In many ways it is similar to the Euandropogoneae section and is occasionally placed there; however, most recent workers seem to agree that it belongs in the Rottboellieae (Keng 1939). The genus has a rather interesting disjunct distribution, being an abundant and important part of the grassland flora in both Africa and America (Bews 1929, Pilger 1940).

The species under consideration in this study, *E. argenteus* Nees., is widely distributed in South and East Africa and according to Chippindall (1955) is occasionally dominant in the open grasslands of eastern South Africa.

The material used for this study was supplied by E. R. Roux of the Department of Botany, University of Witwatersrand, from a native seed collection near Johannesburg, South Africa. The plants were grown in the Andropogoneae nursery of the Oklahoma Agricultural Experiment Station as described elsewhere (Celarier and Harlan 1956). Herbarium specimens and bud material were taken under nursery conditions; buds were fixed in Carnoys and refrigerated until studied, and all chromosome studies were made from aceto-carmine smears.

Other than the phylogenetic and evolutionary significance of the $n = 5$ species, there is also considerable purely cytogenetical interest in grasses with such low chromosome numbers, because of their potential value for studies of chromosome behavior, etc.

With this in mind a somewhat detailed report of the chromosomes of this species is given.

Chromosome behavior. Prepachytene stages appear to be fairly clear and distinct but have not been studied in any detail. At pachytene the chromosome pairs are quite elongated and stain very sharply with aceto-carmine. There are definite knobby regions throughout the chromosomes (fig. 1) that stain more intensely (heteropycnotic) but the intercalary ones have not been studied in sufficient detail to be used for identification. However, two or three of the chromosomes have terminal knobs and these are used. It is not yet possible to be entirely sure of the number of these because of a tendency for fusion (figs. 1 and 2).

One pair of chromosomes is always attached to the nucleolus approximately 15 microns from one end (fig. 1), and the remaining four pairs can be separated into two groups by total chromosome length (fig. 2). If we designate the nucleolar organizing chromosome N, the large chromosomes A, and the smaller ones B, the following preliminary summary can be made.

N -ca. 45 microns long, connected to the nucleolus by broad heteropycnotic band.

A_1-ca. 68 microns long, no terminal knob.

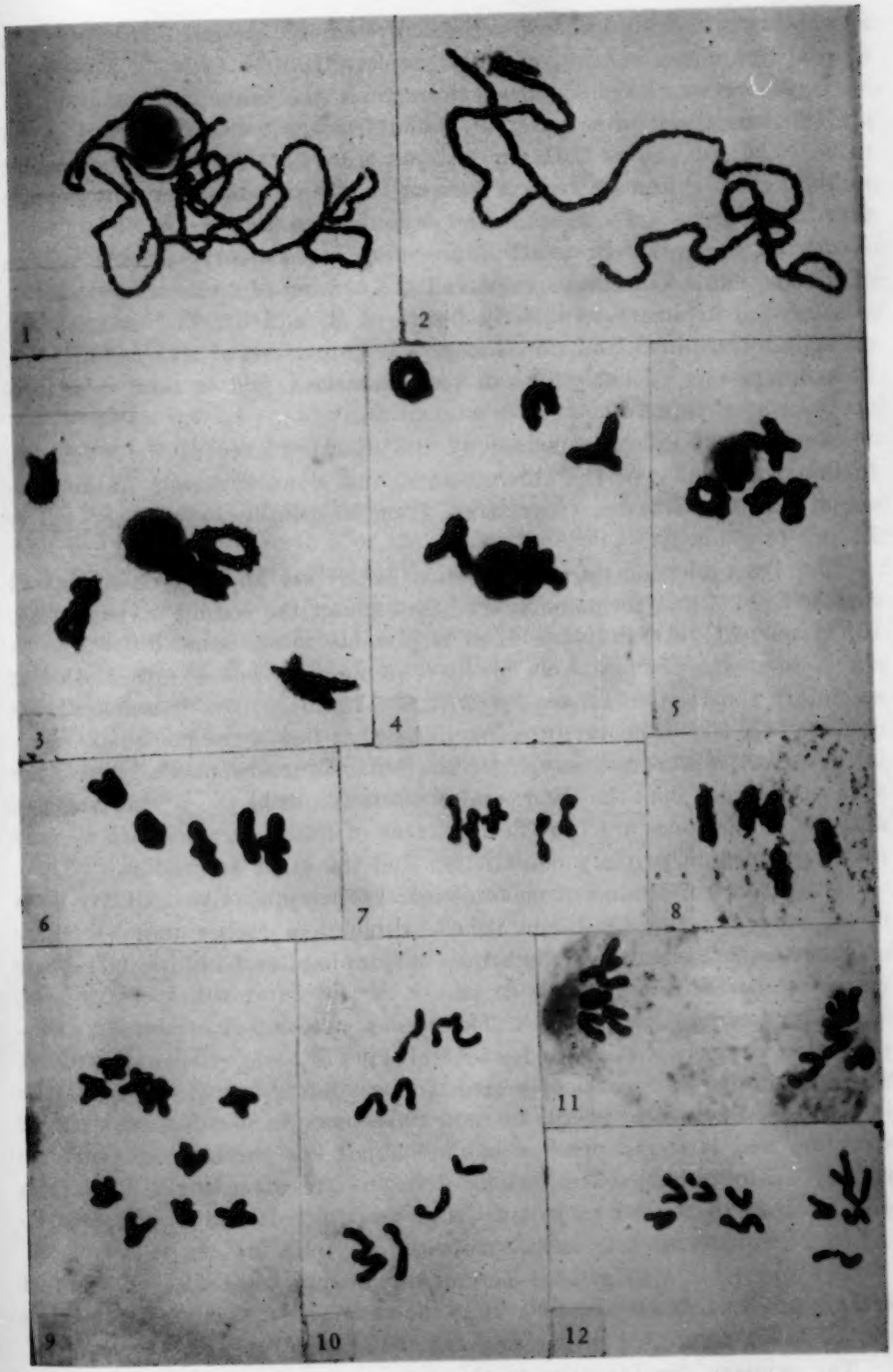
A_2-ca. 58 microns long, with a terminal knob.

B_1-ca. 52 microns long, with a terminal knob.

B_2-ca. 44 microns long, no terminal knob.

All measurements were averages made at pachytene and there are, of course, many factors that cause deviations in length. Comparative measurements of arm lengths one to another are much preferred but could not

FIGS. 1–12. Meiosis in *Elyonurus* and *Sorghum*. 1350×. FIG. 1. Pachytene in *E. argenteus* showing all five pairs of chromosomes, the heteropycnotic band connecting the nucleolus and several smaller heteropycnotic knobs, some of which are terminal. FIG. 2. Pachytene in *E. argenteus* with four chromosome pairs separated from the nucleolus and associated chromosome. Note that two heteropycnotic terminal knobs are fused. FIG. 3. Late diplotene in *E. argenteus* showing five bivalents with 12 chiasmata. FIG. 4. Middiakinesis in *E. argenteus* showing considerable terminalization. FIG. 5. Late diakinesis in *E. argenteus* (Figs. 3, 4, and 5 demonstrate the degrees of chromosome contraction). FIG. 6. Metaphase I in *E. argenteus*. FIG. 7. Metaphase I in *Sorghum stipoideum*. FIG. 8. Metaphase I in *Sorghum intrans* (note the differences in chromosome size in figs. 6, 7, and 8). FIG. 9. Anaphase I in *E. argenteus*. FIG. 10. Anaphase II in *E. argenteus* (only one of the cell pairs shown) demonstrating the differences in size of the chromosomes and position of the centromeres. FIG. 11. Telophase II in *E. argenteus* showing secondary constriction of one chromosome. FIG. 12. Anaphase II of *E. argenteus* showing differences in chromosome size, position of the centromeres, and one chromosome with a recognizable secondary constriction.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be applied in this study because the centromeres were not distinguishable. Special techniques will undoubtedly correct this.

Diplotene is extremely clear throughout the entire process (fig. 3) and chiasma frequencies were calculated from 25 cells. They were found to be 11.56 per cell or 2.31 per bivalent. Since it is not always possible to distinguish chiasmata from a twisting of the chromosomes it is possible that these figures are somewhat higher than actual.

At diakinesis the chromosomes are much more contracted (the process of contraction is a continuous one and the naming of stages of contraction is somewhat arbitrary as seen in figures 3, 4, and 5). The chiasma frequencies, determined from 25 cells, were 10.76 per cell or 2.15 per bivalent. This decrease is probably due to terminalization and is even more pronounced at metaphase.

Metaphase I is characterized by the disappearance of the nucleolus, further contraction of the chromosomes, and a much denser staining reaction (fig. 6). Chiasma frequencies, from 25 cells, were 9.00 per cell or 1.8 per bivalent.

The remainder of the first division is normal and very clear at all stages (fig. 9), and the same is true throughout the second division (figs. 10, 11 and 12). At anaphase II it is possible to see some differences in chromosome morphology. One of the chromosomes has a rather distinct secondary constriction in some cells (figs. 11 and 12) but it is not always obvious (fig. 10). However, it seems likely that this is the nucleolar organizing region of chromosome N. Of the other four chromosomes, two are somewhat larger than the others and are believed to be the A chromosomes, and the smaller ones are B's (fig. 12). One of the A chromosomes appears to have a median primary constriction and the other submedian.

Thus from our studies of meiotic structure it appears that all five pairs of chromosomes can be distinguished, although a rather detailed study of chromosome structure at both meiotic prophase and mitotic metaphase may be required.

Discussion and conclusions. The species, *Elyonorus argenteus*, is apparently extremely well suited for several types of basic cytogenetic studies. The chromosomes are extremely large in size (for grasses) and quite few in number. There are several marked differences in chromosom size and structure and it seems quite probable that all five chromosome pairs are readily distinguishable. The meiotic divisions are exceedingly clear from pachytene to the tetrad spore stage and are well adapted to simple cytological techniques such as aceto-carmine.

The species is a long lived perennial and any interesting types that are produced can be maintained and increased vegetatively. Nevertheless it will flower from seed in one season if handled properly.

The primary disadvantage to this species as an experimental subject

is the sporadic manner in which it flowers. This can probably be overcome by proper photoperiod and/or temperature treatments.

A comparison of *Elyonurus argenteus* with the five chromosomes species of *Sorghum* and *Coix* suggests that it is superior to both of these for many types of cytogenetic studies.

Elyonurus is a long lived perennial whereas *Coix* and the five chromosome *Sorghums* are annuals. Pachytene preparations are clear and easily spread in *Elyonurus* but both *Coix* and the Para-sorghums have rather poor prophases. The chromosomes of *Elyonurus* are apparently somewhat smaller than those of *Coix*, although no direct comparisons could be made. They are considerably larger than *Sorghum* as shown by figures 6, 7, and 8. The average length of MI chromosomes of *Elyonurus* is 6.6 microns whereas the *Sorghum* species are about 6 microns at the same stage. It appears that *Elyonurus argenteus* has the largest known chromosomes in the Andropogoneae (see Celarier 1956b for comparison with *Andropogon*).

The occurrence of another genus with $n = 5$ is offered as more evidence that five is the basic number of the Andropogoneae. This is especially true since this genus is rather distantly related to *Sorghum*, the other genus with five chromosomes. Also the occurrence of $n = 5$ in the Rottboellieae is significant in connection to the possible origin of the Maydeae. It is generally conceded that the Rottboellieae and the Maydeae are closely related and it is now seen that both have species with $n = 5$.

The Rottboellieae is still too poorly known to make any definite conclusions but this is offered as another reason why this section of the Andropogoneae should be given a thorough analysis.

SUMMARY

1. A South African species *Elyonurus argenteus* is found to have five pairs of chromosomes.

2. This is the second genus in the Andropogoneae with this number and is offered as further evidence of five as the basic number of the tribe and also is support of the close relationship of the Andropogoneae and the Maydeae.

3. A somewhat detailed study of meiosis showed that all of the stages from pachytene to the spore tetrad were extremely clear and easy to study. The meiotic behavior was found to be completely regular.

4. The potentials of this species for cytogenetic studies were pointed out. It is a long lived perennial, with low chromosome numbers. The chromosomes are quite large and all five pairs can apparently be distinguished by rather simple techniques.

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BULLETIN OF THE TORREY BOTANICAL CLUB

VOL. 84, NO. 3, PP. 163–174 MAY, 1957

HISTOGENESIS OF THE LEAF AND STRUCTURE OF THE SHOOT APEX IN GLYCINE MAX (L.) MERRILL

C. N. SUN

The organization of the shoot apex and the histogenesis of the leaf have long held the interest of botanists. Numerous papers have dealt with these problems and in the past twenty-five years our knowledge of apical meristems of shoots has been greatly extended. Reviews of literature have been made by Foster (1936, 1941), Philipson (1949) Popham (1951) and Gifford (1954). However, previously only a few species were studied in Leguminosae (Boke 1940); no work has been done along this line on soybean. For this reason, the present investigation was undertaken. This study is concerned with the structure of the shoot apex and histogenesis of the leaf of *Glycine max* (L.) Merrill.

Materials and Methods. Materials used in this investigation were collected from Gibson variety of soybean plants 2 to 15 cm. high. For preparation of serial sections, the fixing reagent which proved to be most successful was Jule's reagent (50% alcohol, 100 c.c.; $ZnCl_2$, 2 gms; glacial acetic acid, 2 c.c.). A series of ethyl and tertiary butyl alcohol was used for dehydrating. Serial sections were cut 7 μ and 8 μ in thickness. A safranin and anilin blue combination (Johansen 1940) was utilized for staining.

General Organography of Glycine Max. *Glycine max* is an herbaceous annual. Mature plants are about 50 cm. in height. The leaves which are produced on the main shoot at the first and second nodes above the cotyledonary node are simple and opposite. But those which are produced on the lateral shoots are trifoliate. The trifoliate leaves are arranged in an alternate phyllotaxy—in the bud the leaves are distichous (fig. 1). The leaflets are entire, oblong or ovate in shape. On a mature leaf they are 40–53 mm. in length and 26–35 mm. in width. A pair of ensiform stipules is located laterally at the base of the leaf. The length of a matured stipule is 4–4.5 mm. The stipules mature earlier than the leaf blade, usually when the leaf is only 3–8 mm. long and 1.5–4 mm. wide.

Trichomes may be found anywhere on the plant, but they are closely packed on the very young leaves and stipules which enclose the shoot apex.

Structure of shoot apex. The vegetative shoot of *Glycine max* terminates in a low dome shaped apex (fig. 10). The size of the apex varies with the stage of the plastochron. Measurements were made above the level of the youngest leaf primordium from serial sections. Diameters varying from 80–120 μ and heights varying from 30 to 50 μ were obtained.

The shoot apex of soybean like that of some other angiosperms may be segregated into four zones. These zones are distinguished from each other

by such features as cell size, degree of vacuolation, staining reaction, plane of cell division, relative frequency of mitosis and relative thickness of cell walls. The shoot apex usually has a two layered tunica. The corpus displays the following zones: (1) a central initiation zone of large less vacuolated cells, (2) a peripheral zone of smaller more deeply staining cells which surrounds the central initiation zone, (3) a rib meristem below the central initiation zone (figs. 2, 10).

The cells of the tunica divide only anticlinally; the outer layer of the tunica produces the epidermal system of the plant. The cells of the tunica layers are homogeneous in structure and uniform in size. They are about 10 μ in diameter. The corpus and the inner tunica layer are responsible for the production of the entire shoot excepting the epidermis.

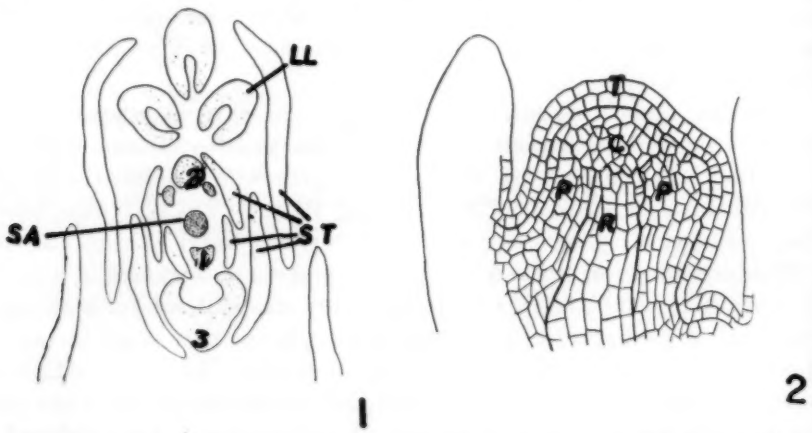
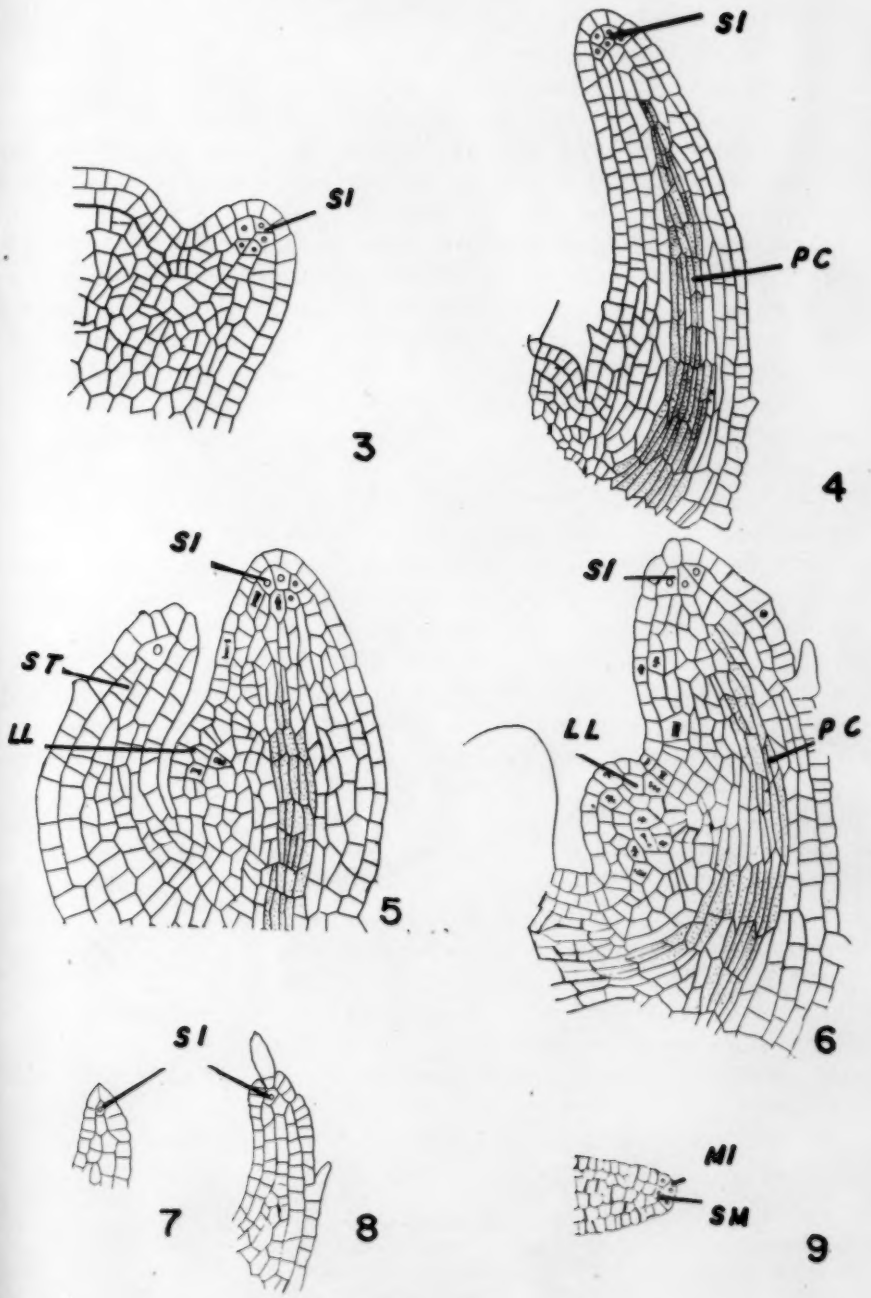


FIG. 1. Diagrammatic representation of the transection of the terminal bud of *Glycine max*, showing the alternate phyllotaxy in distichous arrangement. 1, 2, and 3 indicate progressively older leaf primordia. *LL*. leaflets of the fourth leaf; *SA*. shoot apex; *ST*. stipule. FIG. 2. Longisection of shoot apex showing the location of four meristematic zones (delimited by heavy lines for convenience). *C*. central initiation zone; *P*. peripheral meristem; *R*. rib meristem; *T*. two cell layered tunica. cf. fig. 10. A photomierograph of similar apex.

At the summit of the corpus there is a mass of initial cells from which the rest of the corpus tissues spring. The cells of this zone are isodiametric. They have no conspicuous vacuoles, vary somewhat in size and have an irregular arrangement. On the flanks of the corpus initials, a peripheral zone is produced which is 4 or 5 cells in depth. The peripheral zone is directly concerned with the production of all the vascular tissues, the cortex of the stem, and the foliar organs. The cells of this zone take a deeper stain than do those of the initial zone, and they appear even less vacuolated. Numerous mitotic figures, indicate great activity in cell multiplication. In longisections this zone quite often has a stratified appearance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indicating the tendency of its cells to divide mostly in an anticlinical plane. The rib meristem originates from the base of the central initials. It is composed of cell groups with walls perpendicular to the axis of the shoot apex. The cells are highly vacuolated and display relatively few mitotic figures. This zone is responsible for the production of the pith. Primary pit fields may frequently be seen in the walls of rib meristem cells which are less than 120 μ from the apex.

Leaf initiation and development. Leaf initiation. The leaf primordja were studied from slides of median longisections of shoot apex. When a given primordium has reached a height of about 80–90 μ, the next leaf primordium is initiated. The leaf primordium arises laterally on the shoot apex about 30–50 μ below its summit. Initiation of a leaf primordium may be indicated by anticlinal divisions in the tunica as well as by periclinal divisions in the outer corpus. In most cases, however, periclinal divisions in the corpus appear first (fig. 10).

The first tunica layer (here-after called T-1) maintains its individuality throughout the period of initiation and the subsequent development of the primordium as the result of repeated anticlinal divisions. During the accommodation of this layer to the rapid increase in volume of the primordium, numerous anticlinal divisions occur.

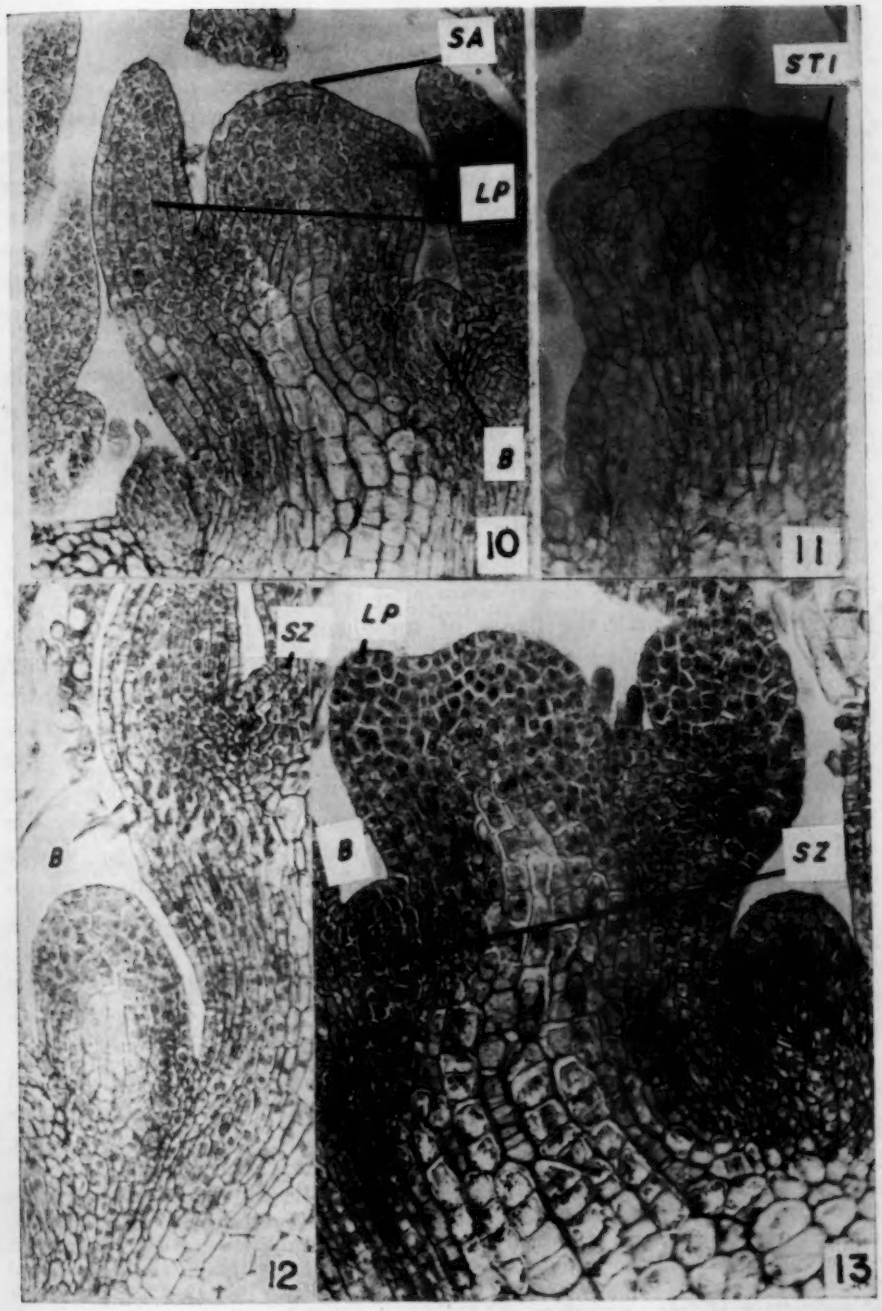
The second tunica layer (here-after called T-2) likewise occurs as a discrete layer, continuous over the stem tip beneath T-1. Periclinal divisions in this layer sometimes occur in connection with the formation of the young leaf, but in most cases T-2 as well as T-1 maintains its individuality throughout the period of initiation.

During the earliest stages of leaf initiation, cells of both the first and second layers of the corpus (here-after called C-1 and C-2) divide periclinally. Further periclinal and oblique divisions then appear in the derivative cells. These groups of cells become adjusted to the rapid elevation of the primordium by means of anticlinal—oblique divisions and elongation.

The procambium nearest the shoot apex is always associated with leaf primordia. It begins to differentiate into the primordium shortly after initiation and is continuous with older procambium. Isolated procambial strands were not observed.

Earlier growth of the leaf. As the primordium continues to enlarge, it appears as a bulge on the flank of the shoot apex and as the result of

FIGS. 3–4. Leaf primordia, nucleated cells represent the subapical initials of the leaf. *PC.* procambium; *SI.* subapical initials. FIGS. 5–6. Stages of leaflets formation. *LL.* primordium of lateral leaflet; *PC.* procambium; *ST.* stipule; *TL.* terminal leaflet. FIGS. 7–8. Longisection of young stipule to show subapical cell. *SI.* subapical cell. FIG. 9. Transection of young stipule, the meristematic margin is shown with nucleated cells. *MI.* marginal initials; *SM.* submarginal initials.


SA
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the continuation of meristematic activity, it becomes a thumb-like protuberance with a somewhat flattened adaxial surface (fig. 13).

As the primordium approached a height of 40 μ, the derivatives of the corpus continue to divide, providing the primordium with a central core. The cells in this region show little evidence of differentiation at this stage.

Continued divergence of the leaf primordium is characterized for some time by a general rapid rate of cell division. At the base of the primordium, rapid periclinal divisions in the adaxial region occur in the derivatives of the corpus, thus giving rise to the procambial tissue. The apical growth results from the division of several subapical initials, most of which have been derived from the inner layer of the tunica (figs. 3, 4).

When the primordium is 120 μ in height, periclinal divisions in the adaxial region still continue. However, the planes of divisions are irregular and are accompanied by rapid vacuolation.

Stipule initiation and development. The histogenetic development of stipules is quite different from that of the leaf. It is in many respects like that of the bud scales of *Carya* (Foster 1935) and *Morus* (Cross 1937). Stipule primordia do not appear until the leaf primordium is nearly 60–80 μ high. They are clearly associated both with the base of the leaf primordium and with the flanks of the shoot apex. Indeed, in certain longisections, they may appear to be derived directly from the shoot apex as the leaf primordium (fig. 11). In all probability, however, the region from which they are formed may best be interpreted as an extension of the base of the leaf primordium. The stipule primordia are first evidenced by periclinal cell divisions occurring in T-1. For this reason this layer maintains its individuality throughout the period of initiation and early development. Shortly after initiation the outer layer of the corpus also divides; subsequent enlargement of the derivatives of the tunica and corpus results in the appearance of two bulges on opposite sides of the leaf primordium and in contact with the shoot apex.

The greater part of the young stipule manifestly consists of derivatives of the inner layer of the tunica which have enlarged considerably, although the corpus contributes slightly to the base of the stipule.

Near the tip of the stipular primordium, there is a subapical cell (figs. 7, 8). This cell apparently undergoes successive anticlinal and periclinal divisions. Following this stage, a rapid increase in length occurs.

FIG. 10. Photomicrograph of a longisection of shoot apex showing leaf initiation from C-1 and C-2. *B.* axillary bud; *LP.* leaf primordium; SA. shoot apex. × 220. FIG. 11. Photomicrograph of stipule initiation, showing the periclinal divisions in the inner layer of the tunica. *STI.* stipule initials. × 240. FIG. 12. Photomicrograph of developmental stages of axillary bud. *B.* axillary bud; *SZ,* shell zone. × 240. FIG. 13. Photomicrograph of early stage of leaf primordium and developmental stages of the axillary buds. *B.* axillary bud; *LP.* leaf primordium; *SZ.* shell zone. × 240.

The increased length results from activity in the epidermal and subepidermal cells which are derivatives of the outer layer and the inner layer of the tunica respectively. This large triangular subapical cell is at the apex of a subapical row of cells which is continuous over the tip from one margin of the stipule to the other. A plate-like core of tissue enclosed by the young epidermis is produced by the subapical row.

Apical and marginal growth continue until the stipules are about 500 μ in height. Up to this time, each member of the submarginal row of initials functions like an apical cell with two cutting faces. Most preparations clearly indicate that cells initiating marginal growth are descendants of T-1 and T-2. The submarginal rows contribute to marginal growth in the same manner that the apical cell increases the vertical extent of the stipule (fig. 9).

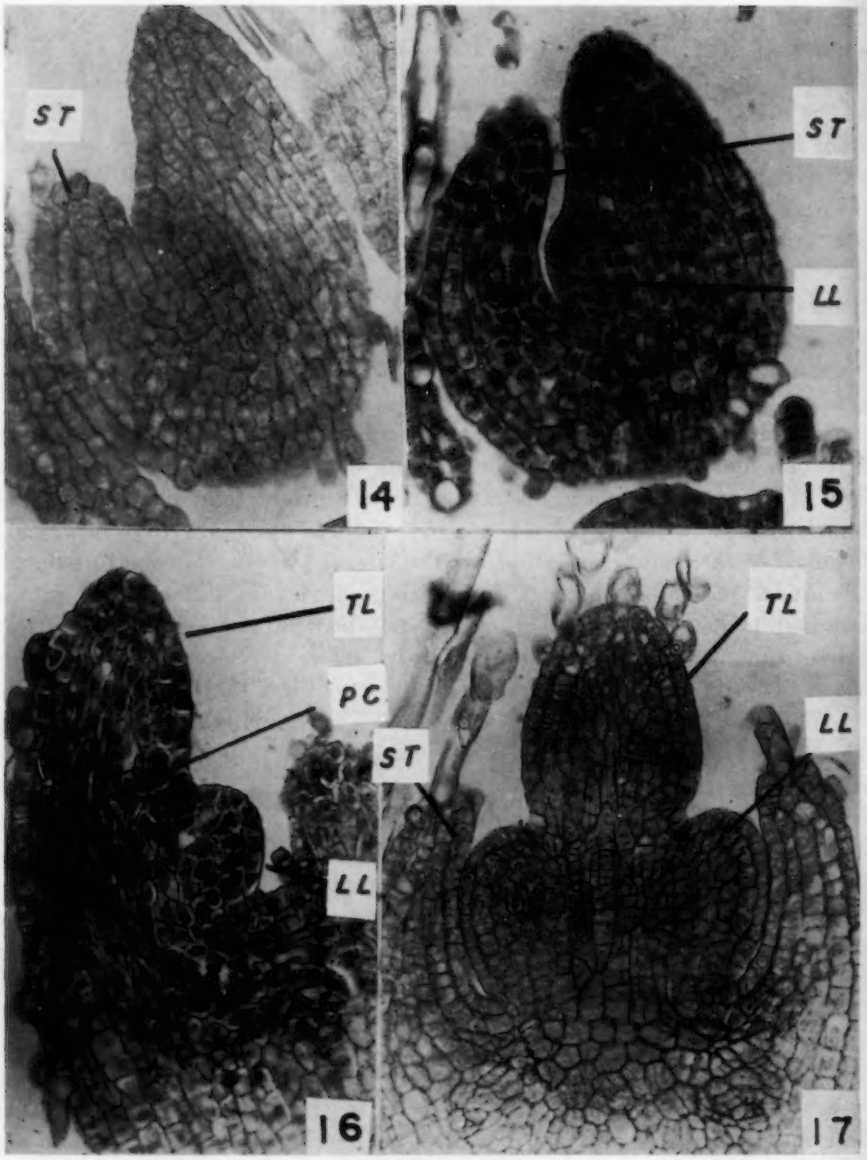
Leaflet formation. When the leaf primordium is 140–200 μ high, cell divisions increase at two opposing points on the adaxial margins at the base of the primordium. This results in the production of two papillate leaflet primordia (figs. 5, 6, 14, 15, 16). Cells in the outer four layers are involved in the leaflet formation. As the lateral leaflets continue to enlarge, the apical region of the leaf primordium begins to differentiate into a terminal leaflet (figs. 16, 17). When the leaflets are initiated, the leaf primordium is complete but sessile. In later development, the region below the pair of lateral leaflets is destined to form the petiole.

When the leaf primordia are about 380 μ high, laminal initiation starts. The first appearance of the blade meristem is indicated by increased mitotic activity in the cells of the marginal regions of the leaflets. Then from the adaxial marginal regions of each leaflet, two delicate ridges are developed. These ridges first make their appearance near the base of the leaflets. From that point they develop acropetally toward the apex.

In the blade meristem, six definite layers of cells are organized. In the first and sixth layers only anticlinal divisions occur. Beneath the epidermal initials, a group of submarginal cells appears to be the initial of the entire central portion of the lamina, from which the inner layers of the blade meristem originate.

The six organized layers mentioned above later on develop into seven layers by periclinal divisions of the cells in the third abaxial layer. The first and seventh layers are destined to develop into upper and lower epidermis. The second and third layers will develop into palisade layers. Cells of the middle layer contribute in part to the tissue of the veins. Most cells of this layer will develop into spongy parenchyma. The fifth and sixth layers are destined to develop into spongy layers.

Initiation and development of axillary bud. The axillary bud arises in the axil of the leaf. It may first be seen in the axil of the second leaf pri-



FIGS. 14–17. Photomicrograph of leaflet formation: *LL.* primordium of lateral leaflet; *PC.* procambium; *ST.* stipule; *TL.* terminal leaflet. ×240.

mordium from the apex. Its initiation is evidenced by periclinal divisions in several cells of the outer layer of the corpus. The initial cells can be recognized by frequent mitotic divisions and darkly stained contents. They are just adaxial to the base of the leaf primordium and are a part

of the apical meristem. By the formation of a "shell zone," a region of elongated cells, and by vacuolation of adjacent cells, the group of meristematic cells in the axil of the leaf primordium becomes delimited from the apical meristem (figs. 12, 13).

The young bud primordium grows rapidly; later on, the zonation characteristic of the main apex is differentiated in the corpus of the axillary bud. The central initial zone, however, consists of fewer cells, and the apex of the axillary bud is much smaller than the main apex. It is usually about 65 μ in diameter, whereas the main apex may be 120 μ.

Discussion. Zonations in the shoot apices of angiosperms were reported by Boke (1941) on *Trichocereus spachianus* and *Opuntia cylindrica*. In both species, the surface cells of the apex form a discrete layer or tunica. A zonal pattern occurs in the internal tissue of the apex. From the side and base of the well defined zone of vacuolated, irregularly arranged thick-walled cells there arise respectively a peripheral zone and a rib meristem zone. Subsequent investigations have shown the general occurrence of zonation within the shoot apices of angiosperms. This study shows that the shoot apex of *Glycine max* also displays zonation.

Previous studies on leaf initiation show that when the shoot apex has a 1-layered tunica, the leaves arise from the outer corpus. When the shoot apex has a 2-layered tunica, both tunica and corpus are involved in leaf initiation. When shoot apices have a 3 to 4-layered tunica, the leaves are initiated in the inner layers of the tunica. Schmidt (1924) found that in *Scrophularia nodosa* the tunica is represented by a single layer, and the leaf arises from the outer portion of the corpus. In contrast, the shoot apex of *Vinca minor* L. possesses a three layered tunica from the inner layers of which the leaf originated. An intermediate condition is illustrated by *Veronica myrtifolia* Sm.; the tunica is represented by two layers, and the leaf arises from both tunica and corpus. According to Rudiger's (1939) observation, *Allium porrum* has a 1-layered tunica, and the leaf arises from the corpus. In *Tradescantia* and *Vanilla*, the tunica is represented by three cell layers and the leaf arises from the tunica only. On the other hand, the investigations of Foster (1935) on *Carya buckleyi* var *Arkansana* and Cross (1937) on *Morus alba*, clearly show a two-layered tunica, and the leaves arise from both the tunica and corpus. Although the shoot apex of *G. max* possesses a two-layered tunica, leaves are intiated in the outer portion of the corpus. Therefore leaf initiation in soybean is different from the type mentioned above.

Various interpretations have been made on the foliar nature of the stipules. Agardh (1849) and Clos (1879) regarded the stipules as independent organs homologous with the adjacent leaf, but their opinion of stipules has not received general support from botanists. Trécul (1853)

and Colomb (1887) regarded the stipules as products of the leaf base. The earliest generalization concerning stipules is that of Eichler (1861) who thought that the stipules are integral portions of the base of the leaf. His interpretation was supported later on by Sinnott and Bailey (1914). But Ponzo (1934) had a different concept; he regarded stipules as divergences from the base of the foliage leaf. Cross (1937) reported that the stipular primordia of *Morus alba* diverge laterally from the leaf base and that their ontogenetic development is different from that of the leaf. The present study confirms Cross' findings.

Opinions differ as to whether axillary buds are formed by the persistence of portions of the apical meristem or whether they arise later by the regeneration of vacuolated cells. According to the interpretation of Koch (1891), Goebel (1905), Schmidt (1924), Louis (1935) and Miller and Wetmore (1946), a bud primordium is derived directly from a portion of the apical meristem, which becomes isolated by the maturation of adjacent cells. In contrast to the above interpretation, Vöchting (1874), Priestly and Swingle (1929), Majumdar (1942), and Majumdar and Datta (1946) described the origin of bud meristems from the vacuolated tissues of the leaf base.

Axillary buds of *Hieracium* (Philipson 1948) and *Syringa* (Garrison 1949) originate as detached meristems. The "shell zone" formation of the axillary meristem has been described by Schmidt (1924), Garrison (1949) and Gifford (1951). The present investigation, indicates that axillary buds of *Glycine max* originate from a group of meristematic cells located just adaxial to each leaf primordium. These cells do not become detached from the apical meristem until sometime after the bud is initiated, at which time the shell zone pattern appears.

SUMMARY

1. The shoot apex of *Glycine max* is a low dome of meristematic cells varying from 80 μ to 120 μ in diameter. Four zones may be delimited: the tunica, the central initiation zone, the peripheral zone, and the rib meristem zone. The tunica consists of two layers of cells.

2. The leaf primordium is first indicated by periclinal divisions in the outer corpus layers. When the leaf primordium has reached a height of about 80 μ to 90 μ the next leaf is initiated.

3. Stipules are initiated at both sides of the base of the leaf primordium when it is about 60 μ to 80 μ high. They arise from the inner tunica layer; the outer corpus contributes slightly to the base of the stipule.

4. When the leaf primordium is 140 μ to 200 μ in height the opposite lateral leaflets begin to form at the adaxial margins of the primordium. Increased cell divisions in these regions elevate the two papillate pri-

mordia. In the meantime, the apical region of the leaf primordium differentiates into a terminal leaflet.

5. Laminal initiation starts when the leaf is 380 μ high. Later on there are six definite layers of cells in the blade meristem.

6. The axillary bud appears in the axil of the second leaf. The initial cells are just adaxial to the base of the leaf primordium and are at first continuous with the apical meristem. Later on a narrow "shell zone" is formed surrounding the group of initial derivatives.

This work was done at the University of Oklahoma, Norman, Oklahoma. The writer wishes to thank Dr. N. H. Boke for his kind advice during the investigation. The writer also wishes to express his appreciation to Dr. H. W. Larsh for use of laboratory facilities.

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REDISCOVERY OF A RARE LOBELIOID, BRIGHAMIA INSIGNIS FORMA CITRINA, IN KAUAI, HAWAIIAN ISLANDS

BENJAMIN C. STONE

Brighamia is a monotypic genus found only in the Hawaiian Islands, growing on steep cliffs in Kauai and Molokai, and at least as late as Rock's monograph (1919), on the small islands of Niihau and Lanai. It is one of the seven indigenous genera of Lobeliaceae, of which six (*Brighamia, Cyanea, Clermontia, Delissea, Rollandia,* and *Trematolobelia*) are endemic, and one *Lobelia*, is found elsewhere. All of the native species are woody, and most of them are truly arborescent; the majority are single-trunked or rather sparsely branched, though some are quite abundantly branched.

The genus *Brighamia* was described by Asa Gray, with one species, *B. insignis* A. Gray (in Mann, 1868). It differs strikingly from the other genera in its thick, fleshy single trunk, which is usually 1 or 2 m. tall, but according to Rock (1919), may attain a height of 5 m. The leaves are clustered at the top of the trunk, giving an appearance according to Hillebrand (1888) of a "cabbage stuck on a fence pole." The leaves are simple, rounded-obovate, subsessile, slightly crenate, 20–30 cm. long by 12–15 cm. wide or smaller. The flowers are long straight tubes with 5 (sometimes 4 or 6) lobes, white or somewhat cream-colored in the typical form; they are borne at the top of the trunk on pedicels of some 10 mm. length, 5 to 15 in erect axillary racemes. The sap of the trunk is watery, unlike the glutinous milky sap of the other genera. The plants are shallowly rooted and seem rather precariously attached for an existence on windy, steep cliffs, their only habitat.

The forma *citrina* was described by Charles N. Forbes and J. M. Lydgate (1917), differing in the lemon yellow corollas, the shorter calyx teeth, and the more acute corolla lobes. The type locality given was simply "Haupu range near Nawiliwili Bay, Kauai; flowering; October 31, 1916; Forbes number 706-K."

Haupu is a low but precipitous isolated mountain range in southeastern Kauai, with a main ridge running east-west for about seven miles, and several shorter ridges projecting south and north. The summit is 2280 feet high, and about 2 miles from the sea coast. The two longest ridges project in a south-westerly direction, bounding a U-shaped valley whose floor at 50 feet elevation is cultivated sugarcane fields. The summits and southern faces of the Haupu range are well-forested; the northern face is vertical, covered with low vegetation; and the eastern face is composed of grassy steep slopes beset with outcrops of rock. Haupu was ascended on December 31, 1956, by Prof. Harold St. John, of the University of Hawaii, Irwin Lane, H. Wool-

ford, Nancy Higgins, and the writer, guided by local residents of Koloa. While ascending the east face, three plants of *Brighamia* were seen, growing on narrow ledges of rock at about 850 feet elevation. Two of the plants were large healthy specimens, about three feet tall; the third was very small and probably a recent seedling. A precise locality can now be given for the forma *citrina* Forbes & Lydgate:

> . . . on outcrops of rock at about 850 feet elevation on the south-east facing slope of Haupu's eastern side; in rock crevices and on narrow ledges, with a sparse growth of *Sida*, weedy grasses, and guava; in the *a'apua'a* (Hawaiian land section) of Mahaulepu, KAUAI, Hawaiian Islands.

The plants found were not in flower, so there may be some doubt as to the identity; but because of their rarity, it is unlikely that the typical form includes these individuals. The nearest locality known is along the Napali coast, on the northwest extremity of Kauai, nearly 30 miles distant, and separated by extensive ranges up to 5170 feet in height; and as far as is known, *Brighamia* has not been collected or seen on Haupu since the original type collection. Although the ravages of wild goats have done much to destroy the natural vegetation of Haupu, as well as other areas, *Brighamia* has survived, at least to the extent of three individuals, likely the descendants of the individuals from which Forbes collected the type of forma *citrina*. It is hoped that in the summer of 1957 a collection of the flowers can be made from these plants.

Other known localities for *Brighamia* (typical) include: Kalalau Trail, Napali Coast, Kauai (B. C. Stone 1475); Niihau (probably-) (Remy 309); steep slopes of Halawa valley, Molokai (Rock 8817); Kalaupapa-Kalawao-Waikolu, Molokai (Rock 8817-A); Halawa, Molokai (Abbe Urbain Faurie 574); head of Maunalei valley, Lanai (Rock, observation). The Hawaiian names are "alulu" (on Kauai) and "pua'ala" (on Molokai).

Another occurrence of a rather rare plant on Haupu might be noted here; *Marattia Douglasii* Baker, the only endemic Hawaiian Marattia, was found in the upper slopes near the summit of Haupu, and on the summit; a number of individuals were seen with fronds up to eight feet long, the longest seen on this species, exceeding the length given in Hillebrand's description (1888) by 3 feet. Although Hillebrand mentioned this plant as rather common, it is only locally common in certain small areas. Another known locality is on the slopes of east Maui.

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BULLETIN OF THE TORREY BOTANICAL CLUB

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THE STOMATAL APPARATUS OF EQUISETUM

RICHARD L. HAUKE[1]

Morphologists do not agree on the structure of the stomatal apparatus of the genus *Equisetum*. In fact, a review of the literature shows wide divergence of opinion as to its correct interpretation.

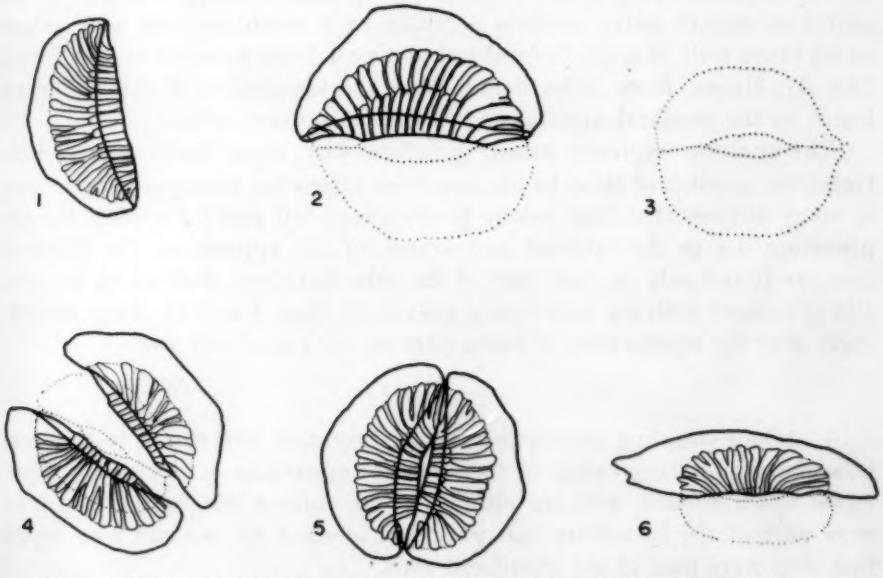
The stomatal apparatus of *Equisetum*, because of its unique structure and because of its taxonomic importance in the division of the genus into two sections, has long attracted the attention of botanists. This apparatus consists of two pairs of cells, one completely overlying the other. Between the two pairs there are conspicuous and unique ridge-like thickenings radiating outward from the stomatal slit. In one section of the genus, sec. *Euequisetum*, this apparatus is flush with the epidermis and the stomata are scattered or in broad bands on the sides of the grooves of the stem. In the other section of the genus, sec. *Hippochaete*, the stomata are sunken and arranged in narrow bands of one or a few files. There are also differences in the shape of the cells and in the structure of the radiating ridges. In *Euequisetum* the cells of the external pair are about four times as long as wide, and the ridges are continuous, whereas in *Hippochaete* the cells are only twice as long as wide and the ridges are notched at about their midpoint. (cf. figs. 2 and 6).

Sanio (1858), using the techniques of dissolving the silica with caustic potash to see the cell walls, of burning out the organic matter to see the silica coating, and of maceration, studied the epidermis of *Equisetum*. He stated that the stomata consisted of two pairs of cells, an outer and an inner pair, and that the outer pair had radiating stripes on its lower wall. Duval-Jouve (1864) described the ontogeny of the stomata as follows. The mother cell divides longitudinally to produce two cells lying side by side, with a slit developing between them. Each of these cells then divides tangentially to produce two cells, one internal to the other. The wall between them has thickenings, which belong to the outer cell. Strasburger (1865) disagreed with this account. He said that the mother cell divides obliquely and the larger of the two cells divides obliquely again, to produce a total of three cells, a lenticular cell between two crescent-shaped ones. The central cell then divides longitudinally into two lateral cells, and a slit develops between them. Meanwhile, the two crescent-shaped cells overgrow the two central cells, to produce the characteristic arrangement. Strasburger pointed out that the two outer cells were sub-

[1] This problem was suggested by and the work initiated under the direction of Dr. Adriance S. Foster, University of California, Berkeley, and the paper was prepared with the help of Dr. Warren H. Wagner, Jr.

sidiary cells and that the inner pair were the true guard cells. This writer's observations confirm Strasburger's account of the ontogeny of the stomatal cells. However, the statement was also made by Strasburger that the thickened ridges belonged, not to the outer pair (as Sanio and Duval-Jouve had stated), but to the inner, or guard cell, pair. This, then, is the point, namely the location of the ridges, which has become the source of variance in descriptions of *Equisetum* stomata.

No one has ever disagreed with his account of the ontogeny of the stomatal apparatus, but from the time of Strasburger there has been great disagreement concerning the radiating ridges on the wall between the guard cell and the subsidiary cell. Milde (1867), De Bary (1882), Luerssen



FIGS. 1–6. Camera lucida drawings of isolated stomatal cells. × 400. FIG. 1. Subsidiary cell of *E. variegatum* var. *nelsoni* showing the radiating ridges on its lower wall. FIG. 2. Guard cell pair overlain by a single subsidiary cell in *E. laevigatum* showing the smooth wall of the guard cells. FIG. 3. Guard cell pair in *E. laevigatum* completely isolated. FIG. 4. Subsidiary cell pair in *E. hyemale* partially separated to show the underlying guard cell pair. FIG. 5. Subsidiary cell pair in *E. variegatum* var. *nelsoni*. FIG. 6. Guard cell pair overlain by one subsidiary cell in *E. litorale*.

(1889), and Riebner (1925), all stated that these ridges belong to the subsidiary cell, whereas Thomas (1911), Copeland (1902, 1936), Johnson (1933), Ziegenspeck (1938), and Korsmo (1954), all believed that the thickenings are part of the guard cell wall. In view of this discrepancy in the literature a study was undertaken to resolve it and determine the location of these thickenings.

Materials and methods. Dried material of twelve species of *Equisetum*

was boiled in alcohol to wet it and to remove the air. This material was then placed in a solution of equal parts 50% hydrofluoric acid and 70% ethyl alcohol for two days to desilicify it, washed, cleared for two days in 10% sodium hydroxide, washed again, and macerated in equal parts 10% chromic acid and 10% nitric acid until mushy. It was then stained in an alcoholic solution of safranin for two days, counterstained with an alcoholic solution of fast green for a few minutes, teased apart and mounted in diaphane.

Results and discussion. In all species isolated subsidiary cells were found to possess radiating ridges on the wall that had been adjacent to the guard cell (fig. 1), and in many cases an isolated stomatal apparatus was found intact except for one subsidiary cell, thus showing the guard cell pair with smooth walls, overlain partially by a subsidiary cell with ridges on its inner wall (fig. 2). Several isolated guard cell pairs were also found (fig. 3). Hence, there is no doubt as to the association of the radiating bands in the stomatal apparatus with the subsidiary cells.

The question naturally arises, therefore, why, since Sanio clearly illustrated the position of these bands, has there arisen the misconception among so many authors that they belong to the guard cell pair? Probably the explanation lies in the external appearance of the apparatus. The thickenings are found only on that part of the subsidiary cell wall which is actually in contact with the underlying guard cell (figs. 4 and 5). They accordingly give the appearance of being part of the guard cell wall.

SUMMARY

1. A long-standing discrepancy in the literature pertaining to the location of the radiating bands in the stomatal apparatus of the genus *Equisetum* was discussed, with the citation of six authors who stated that they were part of the subsidiary cell wall, and another six authors who stated that they were part of the guard cell wall.

2. Macerations were made of desilicified and cleared material of twelve species of *Equisetum*, which revealed that these bands are always located on the subsidiary cell wall, thus confirming Sanio's original report.

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RIB FORMATION IN ASCOSPORES OF NEUROSPORA AND QUESTIONS OF TERMINOLOGY

B. O. DODGE

When Shear and Dodge (1927) were preparing a report covering their studies on the life histories of the so-called red bread molds, questions arose regarding appropriate terms to be used in given situations. Other questions arose later in connection with publications by the writer and others. In some cases nothing was known at the time of the functions of the structures being studied. In other cases the essential facts were well known, but the authors used certain terms rather loosely or even incorrectly. Examples of these two sources of error will be commented on later. *Neurospora* has proved to be such good material for biochemical and genetic studies that any additional information on questions of morphology, stages of development and terminology should be recorded.

While re-reading some of the early papers dealing with the morphology of *Neurospora*, the writer recently came upon two papers, one by Faull (1930), the other by Lindegren and Scott (1937). These authors called attention to the nature of the striations on the ascospores of *Neurospora crassa*. Everyone who has cultured this species is familiar with them. Shear and Dodge called them ridges which sometimes branch; Lindegren and Scott called them ribs which never branch; Faull said they are not ridges at all. These striations are the features that particularly characterize the genus, *Neurospora*. Except for the three papers referred to above very little information has been forthcoming regarding the nature and development of the wall structures and spore contents of species in this genus.

Shear and Dodge (1927) describing the new genus, *Neurospora*, referred to the spores as longitudinally ribbed. Describing the type species they said of the spores: "sometimes branched ribs." They said of the other three species, "sometimes branched ridges." This term, ridges, was the one objected to by Faull (1930). Lindegren and Scott (1937) accepted the term "ribs," but objected to the idea that they ever branch. The writer prefers the term "ribs" and holds that the branching is a false one and more in the nature of an anastomosis. It is a pseudo-branching, not by growth as a tree branches, but by the assemblage of discrete entities in the form of branches.

Lindegren and Scott (1937) believe that there are developed in the young spore, certain rib-forming bodies, *rfb*, to the number of a dozen or more in each end of the spore. Later, these come together loosely at the middle of the spore. Then about half of them move toward one end and most of the others move to the opposite end, and in so doing lay down the ribs.

Early cytologists who studied the formation of the walls of pollen grains,

rust spores and zygospores of the mucors, pointed out that the early stages begin at many points beneath the primary layer of the wall and by intussusception lay down between these wall initials whatever substance the particular kind of spore uses to build its wall.

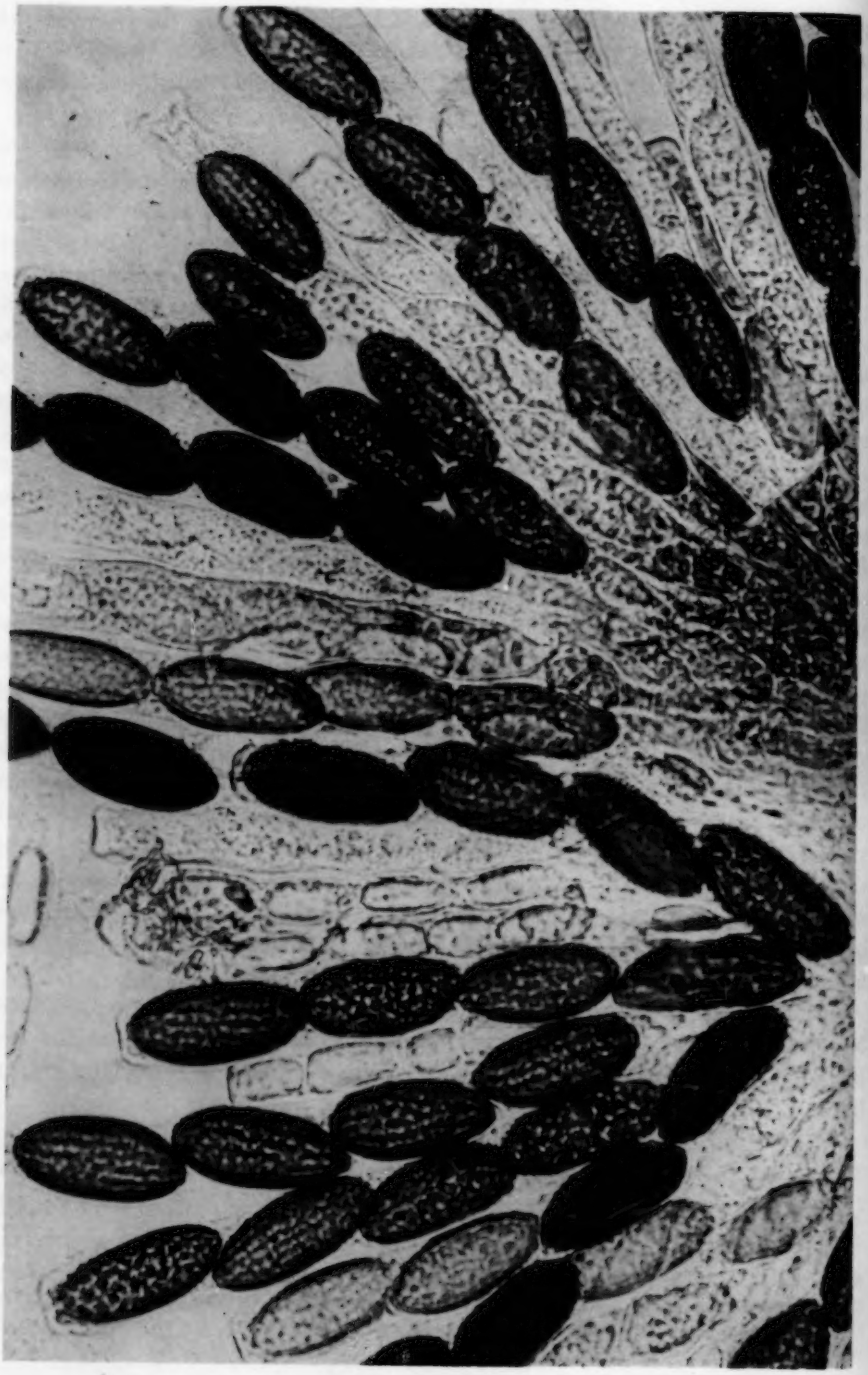
The writer believes that Lindegren and Scott might not have proposed their method of rib formation had they been familiar with the illustrations by the writer (1928) in his plate 4, B. A portion of that figure is brought in here as figure 1, where about half of the original rosette is magnified. It can be seen that in the youngest spores the rib-forming bodies are scattered about irregularly. A little later the bodies begin to line up, five to ten, or more, in a line which sometimes seems to branch. There must be about 100 of these bodies, counting those that are visible only when one looks for them by focusing his microscope. Finally, the *rfb* lines smooth out as the spore matures. See also Dodge (1935, Pl. 9, B) for rib branching.

Lindegren and Scott (1937) accepted the view that ribs in the walls of aborted indurated asci of *N. tetrasperma* (Dodge 1934), are formed the same way they are in ascospores. This raises the question, just how are they formed in indurated aborted asci? Figure 2, A-F, shows various stages, earliest to latest. The reader will obtain a more complete picture of much that goes on here if he compares these figures with two other illustrations by the writer (1934, 1955). Figure 1, A, (1934) presents an excellent picture of rib branching. Curiously enough there seem to be two kinds of ribs, those that are dark colored and those that are not colored. The uncolored stripes show the best "branching." The cross-sections in figure 1, B, C, D, (Dodge 1934), and figure 2, C, D, herein, indicate strongly that the dark colored stripes are the real ribs. Early and intermediate stages are well shown by Dodge (1955) in his figure 2, D right, and A. Ascus No. 3, shows that the rib formers are just beginning to line up. Ascus No. 4 shows at the apex that the rib-forming bodies are still not organized into definite lines, but they are in lines down below in this ascus. Figure 1, C, (Dodge 1934) especially, shows the true nature of the ribs.

Boudier (1871) illustrates, in color, the striations of ascospores of *Ascobolus furfuraceus*. He shows very plainly that the violet striations are bounded by uncolored stripes which anastomose acutely to form long reticulations.

The writer once stained some cross-sections of spores of *N. sitophila* and *N. crassa*. These preparations seem to support Faull's view that the striae (ribs) are not ridges. However, the cross-sections of the indurated asci

FIG. 1. Part of a rosette adapted from Dodge (1928). Successive stages in rib-formation. Young spores show the rib-forming bodies scattered about irregularly. Later they become oriented in definite lines while the little bodies still remain separate. Practically all stages can be followed from the earliest to the mature. A few spores show the false branching.



(fig. 2, C, D) support the opposite view because the sections of ribs are very much like cogs of a cog wheel. When ascospores of *Neurospora* are free-floating in the SMF mounting fluid some of the spores will come to rest in a vertical position. By focusing one sees plainly the individual ribs. Boudier in his Icones, Myc. pl. 410, illustrates the wall characters of ascospores of *Ascobolus striato-punctatus*. The striations certainly look like ridges and resemble somewhat the punctate line of rib-forming bodies shown in figure 1. The main difference is that Boudier figured mature spores while our figure shows very early stages in rib formation. One cannot doubt that there

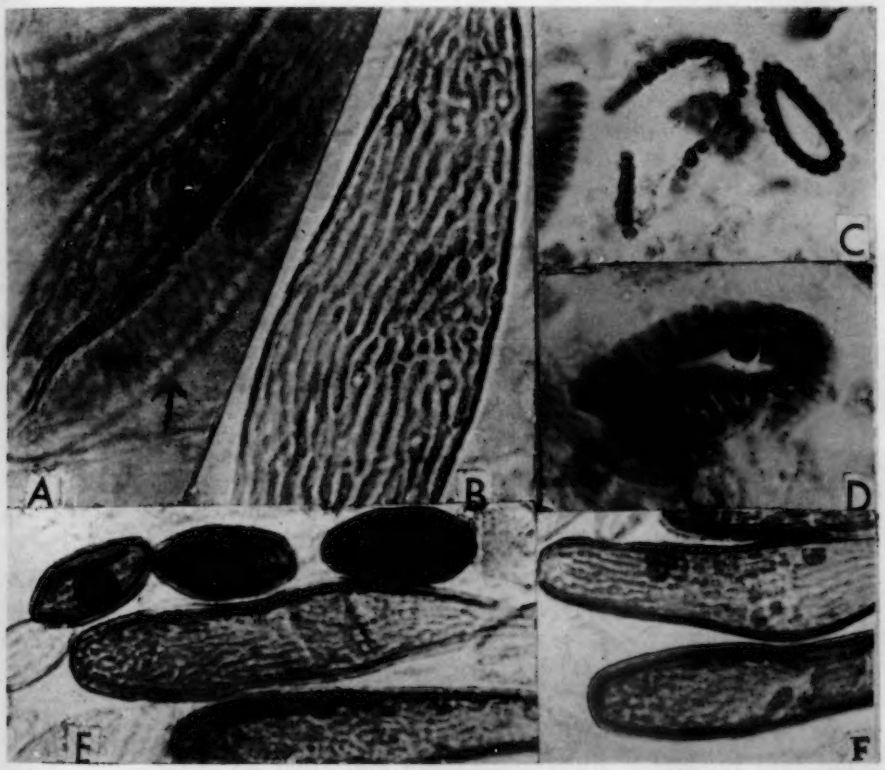


FIG. 2. Stages in the formation of ribs in aborted indurated asci. A. Very early stage where the little spherical rib-forming bodies are mostly scattered about. This young ascus had been pressed down rather flatly. Large numbers of the rib initials can be seen along the edges of the ascus. Must be several hundred of them altogether. B. Mature stage, where rib-branching can be seen. C and D. Cross sections of mature indurated asci. The reader can form his own conclusions as to which, the cog-like blocks or the thin streaks, constitute the real ribs. E. Central ascus shows at the apex that the rib-formers are still not oriented, but farther down they are lining up. F. Ascus above shows a complete lining up of the rib-forming bodies which are still evident, while farther down the lines have become smooth, like those in ascus B. In part from figure 2, Jour. Heredity, No. 1, 1955; other parts from Dodge (1934).

is a pseudo-branching of ribs in the walls of indurated asci of *Neurospora*, whether the light colored stripes or the dark colored blocks are the real ribs. At least we can agree on the term "ribs" in preference to ridges, nerves, striations, etc. As to their branching, the analogy may seem rather far-fetched but looked at from the front the three pairs of vertebrochrondral human ribs present a good picture of false branching of ribs. While cross sections of indurated aborted asci of *N. tetrasperma* show 30 to 50 ribs, cross-sections of ascospores would show only about 15 to 20 ribs. In both cases the number cut across would depend of course on the location of the section.

Other questions of terminology. According to Blakeslee's definition, *N. tetrasperma* would be homothallic. Knowing its complicated life history it is clear that none of the ten or twelve terms that have since been applied to this species is wholly satisfactory. Whitehouse (Biol. Rev. 24: 411–444), aiming to clear up this situation, suggested that homothallism in the Blakeslee sense should be referred to a group "primary homothallism" and *N. tetrasperma* and others like it should be put in a class "secondary homothallism". As a matter of fact, these species are primarily and fundamentally heterothallic. If we introduce gene *E* we obtain heterozygous asci which usually delimit eight spores, four of each mating type. When some one discovers how to make homozygous asci *AaEE* go on to mature spores he would certainly call this new race of *N. tetrasperma* heterothallic. Why not then call *N. tetrasperma* and its like pseudo-homothallic?

Not knowing the function of those little dark-colored bodies that develop in cultures of species of *Neurospora*, Shear and Dodge (1927) called them sclerotia. Backus (1939) reviewed papers by the writer (1932, 1935) and by Dodge and Swift (1933) which proved that the sclerotia function as receptive structures or incipient perithecia, now commonly called protoperithecia. Backus' own contribution was highly important in that he proved that the trichogyne is not just a simple outgrowth from the end cell of the ascogonium. The trichogynous system often branches so that two or three branches may fuse with different conidia. Therefore, one ought to obtain a perithecium with some asci that are genetically unlike. In this connection Lindegren and Scott (1937) state that all the zygotes in the ascus are exactly alike genetically. They must have known that the primary diploid fusion nucleus is the only zygote in an ascus. Another misstatement by these authors should also be corrected. They stated that according to "Dodge (1927)" two sister nuclei in the ascus of *N. tetrasperma* cooperate in cutting out the ascospore. This is just the opposite of what Dodge did say. This is not the place to discuss their views on the nature of "vacuoles" (degeneration products) in deliquescent aborted asci and their relation to supernumerary ascospores without nuclei! Sansome (1956)

reported that she had obtained some asci with more than eight spores. She explained this irregularity principally on the basis of triploidy and polyploidy.

Reporting results obtained by inter-crossing three species of *Neurospora* the writer (1928) used terms, as noted earlier, loosely and even incorrectly. For example, he called the perithecia obtained by crossing two species "true hybrids", and the ascospores and their mycelia hybrid spores and hybrid mycelia. He classed the ascogenous hyphae as diploid when all such structures are actually haploids. One could say they are heterocaryotic or dicaryotic haploids, but never *heterozygous,* and never "dicaryotic diploids" as proposed by Buller (Bot. Rev. 7: 335–431, 1941). He based his lengthy argument in defense of his proposition to redefine the term "diploid" primarily on the idea that to be true dicaryon it must originate and be maintained by conjugate nuclear divisions of its haploid nuclei, citing as a good example the dicaryotic mycelium of the uredinial stage of such rusts as *Puccinia graminis.* The writer, in a short paper on conjugate nuclear division in fungi (Mycologia 34: 302–307), pointed out that no one had proved this to be true for this species. It is gratifying to see that geneticists working with the fungi appreciate the fact that dicaryons are highly interesting and important phenomena, but they are not "diploids". The terms dicaryon and diploid are not synonymous.

The writer (1934) suggested that in *Neurospora* the striae or markings on the ascospores and on the indurated aborted ascus walls represent substances laid down outside the protoplast but within the outermost layer of the original wall in each case. It must be that chitin (fungus chitin), if present, is only one of the substances making up these walls in *Neurospora* which have not, so far as the writer knows, been studied critically, that is, microchemically. Until such a study has been made, one should avoid positive statements as to chitin in these brittle walls.

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VOL. 84, NO. 3, PP. 189–198 MAY, 1957

FOUR NOTABLE UMBELLIFERAE FROM PERU

MILDRED E. MATHIAS AND LINCOLN CONSTANCE

In preparing a taxonomic treatment of Umbelliferae intended for J. F. Macbride's FLORA OF PERU we have encountered several items that appear to warrant comment or description at this time. Three of the four species discussed below were obtained during 1953–1954 by the well known German plant geographer, Dr. Werner Rauh, and Dr. Gerhard Hirsch, both of the Botanisches Institut der Universität Heidelberg. The junior author had the good fortune, while visiting South America on a John Simon Guggenheim Fellowship, to be in the Muséo de la Historia Natural "Javier Prado" in Lima while some of the collections were coming in from the field and to meet Professor Rauh there. Through the good offices of Dr. Ramón Ferreyra, distinguished botanist of the Muséo, who has been helpful to many visiting botanists, some of the specimens were made available for inspection. Later these were sent to Berkeley for identification, both from Lima and from Heidelberg. The fourth item was discovered in a series of unidentified American Umbelliferae collected by our late good friend, Francis W. Pennell, and loaned to us by Dr. C. Earle Smith of the Academy of Natural Sciences of Philadelphia.

To the individuals mentioned we are extremely grateful for the assistance accorded us in the furtherance of our project. The illustrations are from the skilled pen of Dr. Reino Alava, whose work was financed by a grant to the junior author from the National Science Foundation. Leaf clearings of *Azorella* and fruit transections of *Paraselinum* were prepared by Mr. John W. Dawson.

AZORELLA PULVINATA Wedd. Chlor. And. 2: 194, pl. 66, A. 1857. (Fig. 1)

Type locality: "Hab. BOLIVIE: Cordillères de département de La Paz!, aux limites de la végétation phanérogamique," *Weddell.*

Specimens examined: HUANUCO: Huayhuash, rocks, 4900 m., 19 July 1954, *Rauh & Hirsch P 1887.* CUSCO: Salcantay, 4700 m., 3 June 1954, *Rauh & Hirsch P 1483.*

Specimens and photographs of this handsome, cushion-forming *Azorella* were thought to represent an undescribed species when examined cursorily in Lima. A subsequent examination of preserved material obtained by Dr. Rauh and of the literature, however, revealed that the plant approximates closely the description and illustration provided by Weddell of *A. pulvinata* from Bolivia. What appears to be the same species was figured also by Weberbauer (1911, fig. 30; 1945, fig. 35) under the name of *A. multifida* (Ruiz & Pav.) Pers.; part of this figure was reprinted by Francé (1913, p. 229), as his Figure 51, 2. The illustration of a leaf purportedly of *A.*

pulvinata in Domin's classical study of morphology and phylogeny of Umbelliferae (1909, pl. 3, fig. 11) is certainly not of the present species. Weberbauer did not indicate the source of the material from which his figure was drawn.

Especially remarkable are the exceedingly long hairs of the laminal

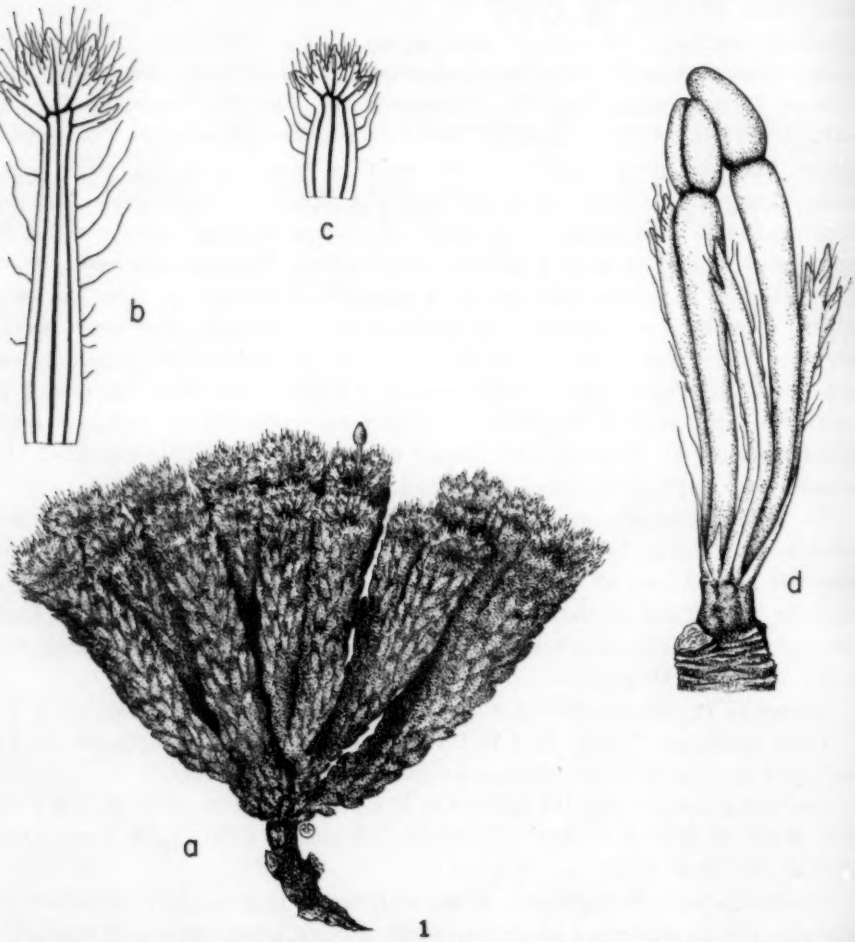

FIG. 1. *Azorella pulvinata* Wedd. a. Habit, ×1. b, c. Cleared foliage leaves, ×2½. d. Umbel, showing involucral bracts, pedicels, and young fruit, ×10. (From *Rauh & Hirsch P 1483.*)

surface, which give the plants a characteristic grayish aspect, and afford the great cushions an attractive frosted appearance. A photograph by Dr. Rauh shows *Azorella pulvinata* growing among cushions of *Werneria dactylophylla* (Compositae) and *Lupinus* sp. (Leguminosae). The long-pedicellate fruits are similar to those of *A. pedunculata* (Spreng.) Math. & Const.

Hydrocotyle Macbridei Math. & Const., sp. nov. (Fig. 2)

Stems slender, creeping, glabrous, the leaves apparently paleaceous and not peltate, 2.5–4 cm. in diameter, trifoliate, appearing 5-foliate because of the bipartition of the lateral leaflets, the leaflets ovate, spinulose-

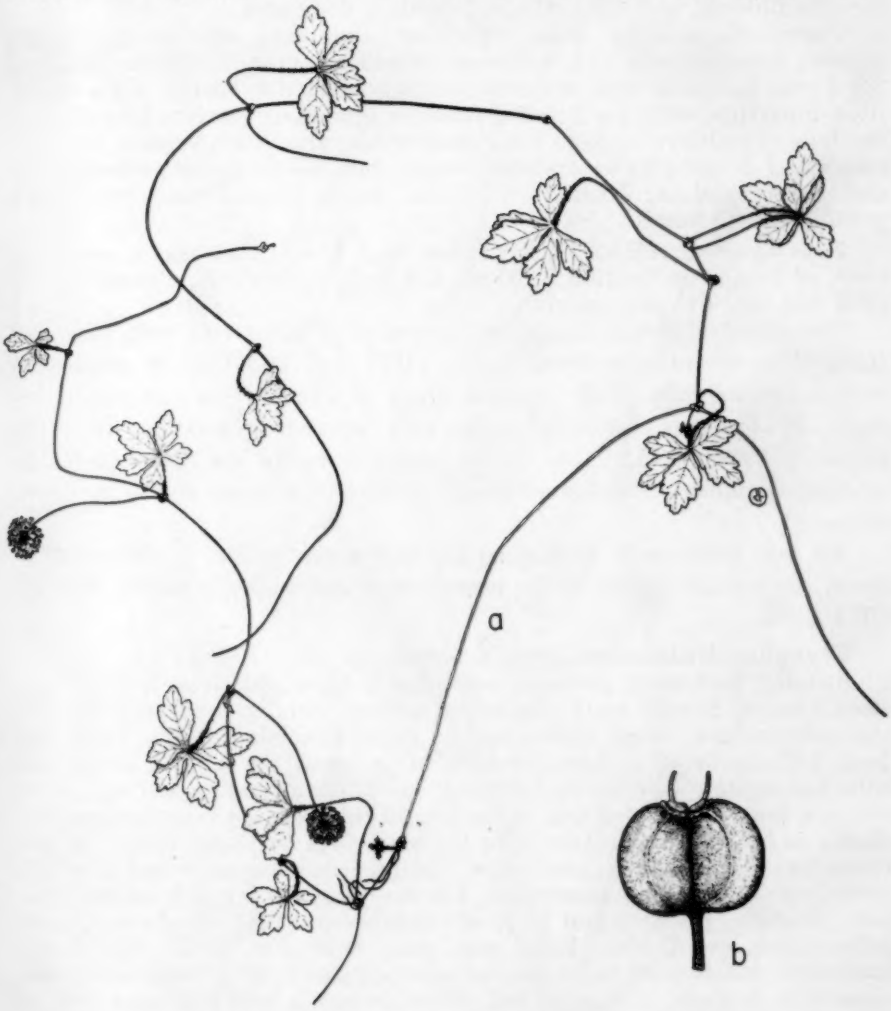

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FIG. 2. *Hydrocotyle Macbridei* Math. & Const. a. *Habit*, ×½. b. Lateral view of mature fruit, × 10. (From the type specimen.)

dentate and shallowly lobed, the lateral bipartite, hirsute on both surfaces, the lobules obtuse, the petioles slender, 1–7 cm. long, retrorse-hirsute at least above; peduncles usually exceeding the leaves, slender, 1–5 cm. long,

glabrous below, retrorse-hirsute at apex; umbels simple, 10–15 mm. in diameter, 35–40-flowered; involucre of several linear-lanceolate bracts 2–3 mm. long, the pedicels slender, 3–5 mm. long, spreading and reflexed, glabrous; fruit transversely elliptical, 1.25 mm. long, 1.5–1.7 mm. broad, the ribs filiform, indistinct, the stylopodium depressed.

Planta *H. nixoides* Math. et Const. simulans; caulibus gracilibus, glabris; foliis palaceis (?) trifoliatis, ut videtur quinquefoliatis, diametro 2.5–4 cm., foliolis ovatis, spinuloso-dentatis et leviter lobatis, lobis lateralibus bipartitis, utrinque hirsutis, petiolis gracilibus retrorso-hirsutis, 1–7 cm. longis; pedunculis quam foliis longioribus, gracilibus, sursum retrorso-hirsutis, 1–5 cm. longis; umbellis simplicibus, 35–40-floris, pedicellis 3–5 mm. longis, glabris; fructibus 1.25 mm. longis, 1.5–1.7 mm. latis, costis gracilibus indistinctis.

Type locality: AMAZONAS: forest bank (loam over clay), mountain south of Tambo de Ventilla, 2900 m., 6–8 July 1948, *F. W. Pennell 15,793* (PH 852,899; UC photograph).

The group of South American species of *Hydrocotyle* with dissected foliage was recently reviewed by us (1951, pp. 302–305) in connection with the description of *H. nixoides* Math. & Const. from Colombian material. *Hydrocotyle Macbridei* is perhaps nearest in relationship to *H. nixoides* (1951, fig. 1A), but differs markedly in its less dissected leaves, much more numerous and much longer-pedicellate flowers, and in its distribution.

We take pleasure in dedicating the new taxon to Mr. J. Francis Macbride, the amiable author of the monumental and endlessly useful FLORA OF PERU.

Eryngium Rauhianum Math. & Const., sp. nov. (Fig. 3)

Slender, caulescent, glabrous perennial 1–1.5 m. tall from a thick rootstock bearing fibrous roots, the stems several, slender, unbranched below the inflorescence; basal leaves rather rigid, linear-lanceolate, 15–25 cm. long, 1–2 cm. broad at base, broadest at or below the middle, acuminate, spinulose-dentate with short, subequal, spreading-ascending solitary spines 3–7 mm. long, mostly 3–8 mm. apart toward the base, the venation parallel; sheath as broad as or broader than the blade, 3–4 cm. long, plane; cauline leaves like the basal, alternate below, the uppermost opposite and bractlike, spreading; inflorescence paniculate, 4–8 dm. long, the lower branches alternate, axillary, the terminal in a 4–6-membered whorl; heads numerous, pedunculate, ovoid, blue, 10–12 mm. long, 8–10 mm. broad, the flowers numerous; bracts 8–10, rigid, curved, spreading-ascending, ovate-lanceolate, acuminate, 4–6 mm. long, subequal, entire or with a lateral spinose tooth, a little scabridulous distally, much shorter than the heads; bractlets like the bracts, ovate-lanceolate, 2–3 mm. long, curved, entire, scabridulous, greatly exceeding the flowers; coma wanting; sepals oval to orbicular, 1.2–1.5 mm. long, 0.8–1 mm. broad, obtuse, mucronulate, blue, scabridulous; petals oval, about 1 mm. long, the narrower, distally bifid, inflexed apex subequal; immature fruit cuneate, 1.5–2 mm. long, 1.5 mm. broad, the lateral scales linear-lanceolate, free, forming a pair of prominent wings, the calycine scales uniseriate, lanceolate to ovate, prominent, the dorsal scales obsolete or wanting.

FIG. 3. *Eryngium Rauhianum* Math. & Const. a. Habit, ×½. b. Basal leaf, ×¼. c. Flowering head, showing bracts and bractlets, ×1½. d. Floral bractlet, ×5. e. Flower, showing immature fruit, carpel scales, sepals, and petals, ×10. f. Petal, showing the inflexed, bifid apex, ×25. (From the type specimen.)

Planta 1–1.5 m. alta, caulibus gracilibus, foliis basalibus 15–25 cm. longis, 1–2 cm. latis, lineari-lanceolatis, spinuloso-dentatis, spinis 3–7 mm. longis, 3–8 mm. inter sese distantibus, solitariis, nervis parallelis, basi vaginantibus, foliis caulinis similibus, inflorescentis paniculatis, capitulis 10–12 mm. longis, 8–10 mm. latis, numerosis, coeruleis, pedunculatis, ovoideis, floribus numerosis, bracteis involucralibus 4–6 mm. longis, ovato-lanceolatis, acuminatis, integris, quam capitulis brevioribus, bracteolis floralibus similibus, quam floribus longioribus, sepalis 1.2–1.5 mm. longis, 0.8–1 mm. latis, ovalibus vel orbicularis, mucronulatis, scabridulous, petalis ovalibus, fructibus immaturis 1.5–2 mm. longis, 1.5 mm. latis, cuneatis, squamis lateralibus lineari-lanceolatis, calycinis uniserialibus, lanceolatis vel ovatis, prominentibus, dorsalibus nullis.

Type locality: CUSCO: Río Marcapata, dry places, 1500–2500 m. alt., 15–20 May 1954, *Rauh & Hirsch P 1279* (UC: type, HEID, SMU).

In Wolff's monographic treatment of *Eryngium* (1913), *E. Rauhianum* would necessarily fall in Section XXXI. PANNICULATA Wolff by virtue of its New World distribution, herbaceous habit, narrow, "monocotyledonoid", parallel-veined leaves with short, marginal spinose teeth, and short-bracteate heads of moderate size. Some 42 species are assigned to this section. On the basis of leaf form, venation, and dimensions, the new species keys to Subsection 2. EUPANNICULATA Wolff, Series 2. PLATYPHYLLA Wolff, and specifically to *E. paniculatum* Cav. & Dombey. This, the first-described South American species of the "monocotyledonoid" Eryngia, appears to us never to have been satisfactorily understood, and Wolff, in effect, throws up his hands at this point. After stating his difficulties in using the characters employed so successfully by Urban (1879), he leaves *E. paniculatum* as a *"typus polymorphous"* or collective species, with the following range: "Andines Südamerika, von Columbien und Ecuador bis Chile und die andin-argentinische Provinz; in der Hylaea, der südbrasilianischen und argentinischen Provinz; nach Süden noch bis in das australisch-antarktische Gebiet hineinreichend (Nord-Patagonien) . . ." (pp. 250–251). The morphological description of *E. paniculatum* is extremely general, and no specimens are cited.

Following the account of *E. paniculatum,* Wolff lists six unnumbered binomials (all the others in this section are numbered): *E. horridum* Malme, *E. eurycephalum* Malme, *E. megapotamicum* Malme, *E. Humboldtii* Delar., *E. Delarocheanum* Wolff, and *E. Malmeanum* Wolff. The last two are presumably "new species," but the designation "nov. spec.", which is employed elsewhere in this volume, is omitted here. For *E. Malmeanum* a single collection is given, but for *E. Delarocheanum* some 25 collections are cited without indication of a type. Inasmuch as *E. Delarocheanum* is given a range which includes southern Peru, Chile (from Valparaíso to Valdivia), Bolivia, southeastern Brazil, Paraguay, Uruguay, and northern Argentina, it is not clear to us just what is intended by this binomial. We are inclined to believe that there may be comprised here an artificial grouping of all

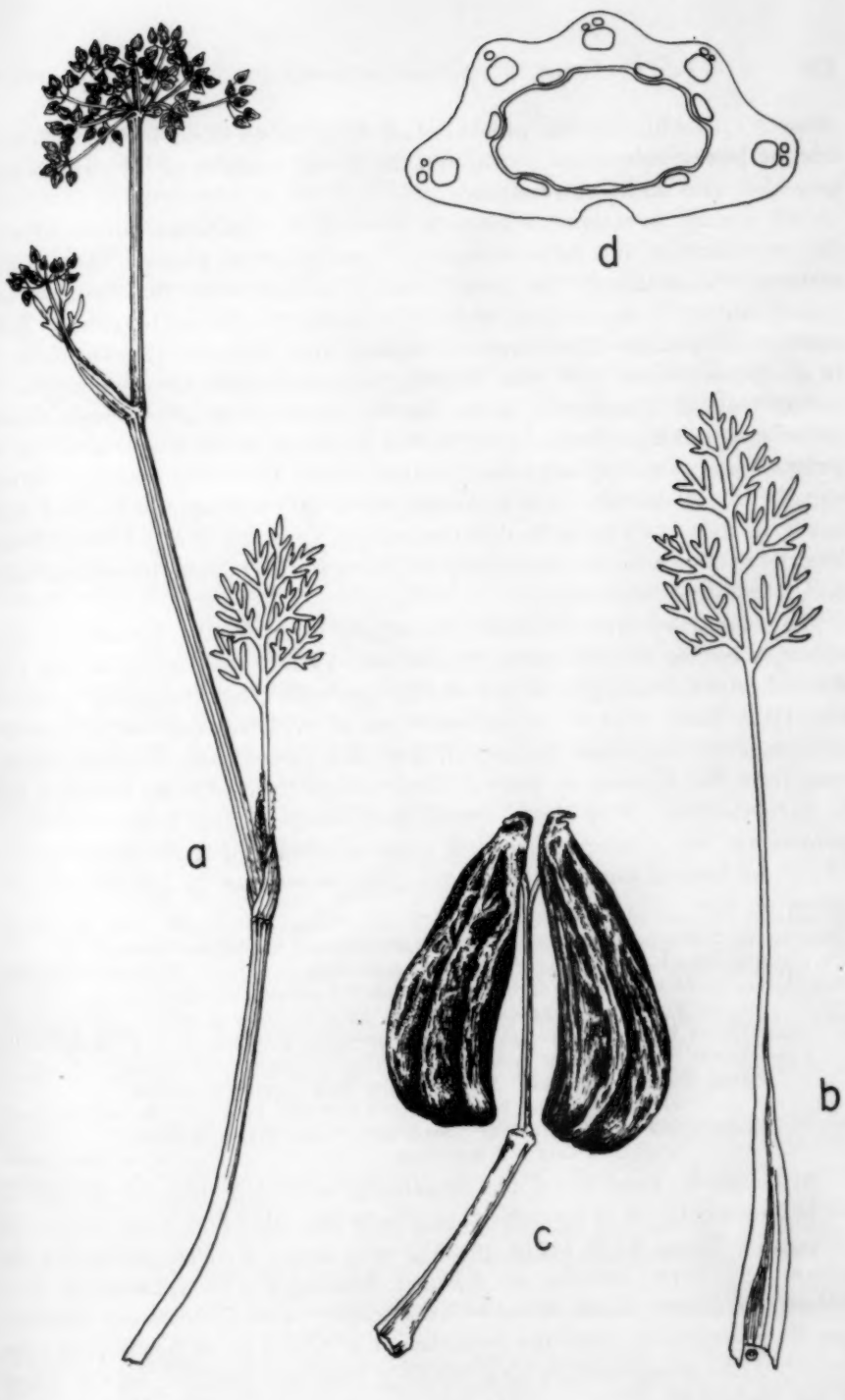

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FIG. 4. *Paraselinum Weberbaueri* Wolff. a. Habit, × ½. b. Lower cauline foliage leaf, × ½. c. Lateral view of mature fruit, showing carpophore and carpels, × 10. d. Transection of mature carpel, × 15. (From *Rauh & Hirsch P 1832.*)

those *E. paniculatum*-like plants which have broad basal leaves, sub-erect cauline leaves, subglobose heads, and the dorsal surfaces of the carpels well provided with scales or vesicles.

We are by no means prepared to solve all the problems connected with the identification and delimitation of *E. paniculatum*, proper. The original material was obtained "in Chihli," and it is extremely abundant, by the junior author's observation, from Coquimbo to Chiloe; material from southern Argentina (Río Negro, Neuquen, and Chubut) appears to us to be the same. While even this material is polymorphic to some degree, it differs from *E. Rauhianum* in its stouter habit and usually more compact inflorescence, longer leaves with bristly marginal teeth much different in proportion, ascending-appressed rather than spreading cauline leaves, usually almost globose and yellowish-green rather than ovoid, dark blue heads, as well as by its quite different range. Very few if any Umbelliferae, in our experience, occur in interior southern Peru and also in central Chile and Argentine Patagonia.

In comparison with the unnumbered species of Wolff's treatment, ours agrees in having the *Gymonota*-type of carpel scaliness (i. e., in having well defined lateral scales plus a row of calycine scales, but the dorsal surfaces essentially bare) with *E. megapotamicum*, *E. Malmeanum*, and *E. eurycephalum*. These three species were all described from Brazil: *E. megapotamicum* from Río Grande do Sul; *E. Malmeanum* from Río de Janeiro, and *E. eurycephalum* from Matto Grosso and Minas Geräes. *Eryngium megapotamicum* has subsequently been reported from Uruguay (Rosengurtt, 1945). An idea of some of the alleged distinctions may be gained from the following key.

Basal leaves 6–10 mm. broad, their spinose teeth 3–4 per cm. of leaf margin, only 1–2 mm. long; heads 8–10 mm. long ..... *E. megapotamicum.*
Basal leaves 10–20 mm. broad, their spinose teeth 0–3 per cm. of leaf margin, 3–15 mm. long; heads 10–15 mm. long.
  Basal leaves broadest above the middle; bractlets glabrous ..... *E. Malmeanum.*
  Basal leaves broadest at or below the middle; bractlets scabridulous.
    Heads hemispherical and broader than long, scarcely colored; bracts 9–11 mm. long; bractlets 6–9 mm. long ..... *E. eurycephalum.*
    Heads ovoid and longer than broad, deep blue; bracts 4–6 mm. long; bractlets 2–3 mm. long ..... *E. Rauhianum.*

Although *E. Rauhianum* has apparently not been properly accounted for taxonomically, it is probable that plants referable here have been cited previously. Thus, Wolff (1913, p. 251) cites under *E. Delarocheanum* the collection: "Peru: Sandia, an felsigen Abhängen (Weberbauer n. 578–blühend im März). Einh. Name: Chuchurapi." And Weberbauer, himself, lists *E. paniculatum* from the Department of Cusco as an herbaceous component of the steppe and *pajonal* between 2000 and 3500 m., on the ridges of the Marcapata (1945, p. 564) and Sandia (1911, p. 238; 1945, p. 568) valleys.

PARASELINUM WEBERBAUERI Wolff, Rep. Spec. Nov. 17: 174. 1921 (Fig. 4)

Type locality: "Anden von Peru, südwestlich von Ayacucho, bei der Hacienda Totonabamba in einem lichten Gehölz, aus höhen Sträuchern und kleinen Bäumen gemischt, 3500 m. ü. M., mit Früchten im Mai," *Weberbauer II-5471.*

Specimen examined: PASCO: Cerro (Cordillera) Raura, chalk rocks, 4400 m., 16 July 1954, *Rauh & Hirsch P 1832.*

Rauh and Hirsch obtained a single, incomplete specimen of this plant, but the available material agrees so closely with Wolff's description as to satisfy us that it represents his "lost" genus. The only real discrepancy is in the carpophore, which Wolff reports to be shortly bifurcate, whereas it is actually parted to the base, but the two halves are closely approximate nearly to the tip, where they diverge sharply to give a deceptively bifurcated appearance.

Paraselinum is reminiscent of *Cotopaxia* Math. & Const. (1952) from Ecuador and *Niphogeton* Schlecht. (Math. & Const. 1951b), a genus ranging from Venezuela to Bolivia. However, it differs from *Cotopaxia* in length of rays, the different involucel, and in its very different carpophore. The dorsal compression of the fruit and the lack of any stylopodium in *Paraselinum* distinguish it clearly from *Niphogeton.*

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TORREYA

Plant Communities of Hutcheson Memorial Forest Based on Shrub Distribution

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I. Introduction

Hutcheson Forest (formerly known as Mettler's Woods) is located on the gently rolling Piedmont of New Jersey. It is an old oak forest which has been preserved with relatively little disturbance. Compared with other forest stands in this part of the country, it has progressed farther in successional development. This led Bard (1952) to say that it "approximates climax." The variable but slight and consequent inefficiency of soil drainage in certain areas reminded Braun (1950, p. 253) of the oak-hickory forest of the Illinoisan till plain. "A type of oak-hickory forest which occurs frequently on the very gently rolling to flattish surface of the Piedmont Lowland is related to high water table. . . . The aspect is similar to that of the Illinoisan till plain forest of the Western Mesophytic Forest region."

Throughout most of the woods the drainage has a dominant influence on the vegetation pattern. Most of the forest is well drained. The poorly-drained portions lie at each end of the forest. A stream, bordered by extensive areas of poor drainage, flows through the eastern section. A small ditch supplements the drainage in the western end. The vegetation associated with well-drained areas is strikingly different from that of poorly-drained areas. Within each, poorly drained or well drained, species composition of the various layers, except for the shrub layer, is remarkably uniform. In contrast such a uniformity does not always exist in the shrub layer. It is with these differences in the shrub layer that this study is concerned.

The objectives of this study are threefold: (1) to prepare a map of the forest utilizing shrubs as indicators, (2) to emphasize the value of employing shrubs in mapping mature forests, and (3) to lay a foundation upon which future studies may be made.

History

Hutcheson Forest is part (65 acres) of an original 1500-acre tract purchased in 1701 by a group of Dutch farmers. This particular section had remained in the possession of the same family from that date until it was purchased and given to Rutgers University. For some reason, the proprietors preserved this fragment from being cleared for agricultural or other purposes since colonial days. If the forests which existed prior to colonization are to be considered as "virgin," then Hutcheson Forest qualifies in this respect.

It has been shown by Buell, Buell, and Small (1954) that fires were relatively common in Hutcheson Forest, occurring at approximately 10-year intervals, before and during early colonial days. Such profound disturbance induced by Indians would seem to preclude the use of the adjective "virgin," meaning undisturbed by human activity, to the colonial forests of this area.

Storms have caused considerable damage to the vegetation in the forest. Numerous trees have fallen during storms and a few others have had top damage. The majority of these has remained in the forest to decay and return to the soil. This is evidenced by numerous logs present in various stages of decomposition. Since storms are a part of the natural environment, the designation "virgin" cannot be denied a forest because it has been damaged by storms. The major alteration is presented when fallen trees are removed. Unfortunately, there were 299 such trees removed after a storm in 1950, and several logging trails remain as evidence. Also, a selective cutting practice of removing an occasional storm-damaged tree prior to 1950 was maintained by the previous proprietor. The western two acres of the forest were cut over in 1872 and cultivated until 1890 (T. H. Mettler, personal communication).

This history of disturbance leads one to question any designation of Hutcheson Forest as a true virgin forest. On the other hand, the 63-acre tract which has not been cut over but has had some fallen and storm-damaged trees removed is as near a virgin forest as exists on the Piedmont of New Jersey today.

II. Methods

The location and extent of the shrub types were determined by reconnaissance. After determining the areas that had distinctly different shrub dominants in the shrub layer, mapping was initiated. Reference points were spaced at 100-foot intervals along the periphery of the forest. Measurements were made from these points along parallel compass lines that extended perpendicularly into the forest until the boundaries of the shrub type under consideration had been determined. All measurements were plotted to scale on outline maps. The points determined by these measurements formed the basis for outlining the vegetative units.

Shrubs could be used in mapping only the mature forest, because in the adjoining young woodlots the shrub layer has not developed to a point where it is a distinct stratum. Such areas were mapped on the basis of physiognomy. In the case of the surrounding fields, a number was assigned for reference.

The size and per cent of area occupied by each shrub type were calculated from the map with the aid of a planimeter. All sizes and percentages given in the text have been rounded to the nearest whole number with the exception of those below a value of 1.

Nomenclature follows Gray's Manual, eighth edition (Fernald, 1950) unless authority is given.

III. Results

Eight distinct shrub types (Fig. 1) based on patterns of shrub distribution are recognized in Hutcheson Forest. They range in area from 51 acres (79%) to 0.1 (0.2%). Four of them are restricted to well-drained sites. Throughout the well-drained areas there is a species similarity among the trees, both of the canopy and under-story, and likewise among the herbs and the bryophytes. Only in the shrub layer are there pronounced differences in species composition. This is equally true of the poorly-drained sites.

A. Shrub Types of Well-drained Areas

The four types of the well-drained sites occupy 82 per cent of the forest.

1. Maple-leaved Viburnum (*Viburnum acerifolium*) Type.

Maple-leaved viburnum constitutes the principal shrub type in the forest (79%) as well as being the dominant shrub on the well-drained sites (95%). Only three small areas of the well-drained portion are occupied by shrubs other than maple-leaved viburnum.

The forest layers above the maple-leaved viburnum consist of an understory tree layer about 35 feet high and a canopy layer that reaches a height of about 95 feet. Between the understory and canopy are frequent trees, either younger trees of the canopy species or species of normally smaller stature. The canopy is for the most part essentially continuous stratum except in the vicinity of wind-throws. White oak (*Quercus alba*), black oak (*Q. velutina*), and red oak (*Q. rubra*) are the dominant species. They comprise by far the major proportion of the total canopy cover. The remaining is contributed mainly by red hickory (*Carya ovalis*) and shagbark hickory (*C. ovata*). White ash (*Fraxinus americana*) and beech (*Fagus grandifolia*) reach the canopy but more commonly, along with sugar maple (*Acer saccharum*), red maple (*A. rubrum*), Norway maple (*A. platanoides*), and sweet cherry (*Prunus avium*), conrtibute to the discontinuous substratum between the understory and the canopy.

The understory layer, which is very pronounced, attains a height of about 35 feet and consists of a continuous layer of flowering dogwood (*Cornus florida*). Interstices are infrequent except in the vicinity of wind-throws. Openings in the understory due to blow-downs are less frequent than in the canopy. Frequent young individuals of canopy species occur with the dogwoods. True understory species other than dogwood are extremely rare.

FIG. 1. Map of Hutcheson Memorial Forest showing patterns of shrub dominance within the forest and showing the adjacent communities. The dashed line that bisects the westernmost *Viburnum dentatum-Smilax rotundifolia* type delimits a two-acre tract that was cleared in 1872.

communities. The dashed line that bisects the westernmost *Viburnum dentatum-Smilax rotundifolia* type delimits a two-acre tract that was cleared in 1872.

Maple-leaved viburnum forms a well-developed shrub stratum that is 3 to 4 feet high. Shrubs other than maple-leaved viburnum are only incidental.

The herbaceous layer is best developed in the early spring before the closing of the canopy. Even though there is a decrease from maximum coverage in early spring to a minimum in late summer, Bard (1952) found that the number of species in the herbaceous flora was greatest in late summer when the cover was the lowest. The herbs can be divided into three groups based on the time of year they initiate growth and their longevity. The first group comprises those plants which begin growth in early spring and deteriorate by mid-summer. May-apple (*Podophyllum peltatum*), spring beauty (*Claytonia virginica*), rueanemone (*Anemonella thalictroides*), and spring cleavers (*Galium aparine*) are the principal species in the spring group. It is this group of species which forms the well-developed spring herbaceous cover. The second group consists of plants which initiate growth in early spring but remain evident until late fall. False Solomon's-seal (*Smilacina racemosa*), Solomon's-seal (*Polygonatum biflorum*), jack-in-the-pulpit (*Arisaema triphyllum*), and *Carex* spp. are the principal species in this group. The third group is comprised of those individuals which begin growth in May and remain evident until late fall. Enchanter's nightshade (*Circaea quadrisulcata*) is the principal species in this group.

The moss layer is the least developed stratum present. Terrestrial mosses are practically absent except on hummocks of old fallen trees, at bases of trees, and along several logging trails (Siburn, 1956). These sites form the only areas with a mineral soil substratum necessary for terrestrial moss growth.

2. Black-haw (*Viburnum prunifolium*) Type.

The forest canopy as well as the dogwood layer where the black-haw type occurs differs from that of the surrounding maple-leaved viburnum type in that it is more open. This aspect is attributable to disturbance associated with the narrowness of the forest. There are several old wind-throws and an old farm road that cuts through at this point. Approximately 2 per cent of the forest is occupied by black-haw.

Stratification is like that of the maple-leaved viburnum area, but species composition differs. The same oaks predominate; red hickory occurs, as well as white ash and sweet cherry. The understory layer consists mainly of dogwood. The shrub layer, predominantly of black-haw is somewhat more open and higher, reaching up to 10 feet in height. The herbaceous layer consists of the same species as in the maple-leaved viburnum type, the major difference being a shift in dominance. Spring-cleavers is the principal herb in the black-haw type. Due to the openness and narrowness of the community, old field herbs are of common occurrence (Bard 1952). Mosses are extremely sparse.

3. Black Cherry (*Prunus serotina*) Type.

The black cherry type occupies 1 per cent of the forest and is entirely situated on the portion that was cleared in 1872. Stratification consists of three definable strata—canopy, shrub, and herb. Scarlet oak (*Quercus coccinea*) is the main constituent of the canopy with black oak and red oak the second and third in importance. A large proportion of these trees is of sprout origin.

The shrub layer is approximately 8 to 10 feet high. It is continuous and quite pronounced as a layer. Although black cherry is a tree species, it forms, in this part of the woods, a low thicket type of growth resulting in this distinctive shrub layer. The individual plants are crooked and terminate in a diffuse branch system.

The herbaceous and moss strata are comparable to that of the maple-leaved viburnum type.

4. Choke-cherry (*Prunus virginiana*) Type.

The choke-cherry area occupies about 0.4 per cent of the woods. The only major difference between it and the maple-leaved viburnum type is in the shrub layer. Choke-cherry forms a well-developed shrub stratum about 5 to 6 feet high with maple-leaved viburnum frequent but overshadowed by the higher choke-cherry.

B. SHRUB TYPES OF POORLY-DRAINED AREAS

Four different shrub types occur on the poorly-drained portions of Hutcheson Forest. They occupy 18 per cent of the woods. These types have a similar physiognomic characteristic: namely, the absence of a definable understory tree layer. Another common feature, with one exception, is the presence of two shrubs as co-dominants.

1. Spicebush-Arrowwood (*Lindera benzoin-Viburnum dentatum*) Type.

The spicebush-arrowwood area is the second largest shrub type in the forest (10%). It is present along the stream and the poorly-drained areas contiguous to the stream.

The canopy over this particular area is sparse, a consequence of wind-throws which resulted from storms in 1950, 1954, and 1955. Approximately 80 per cent of recent wind-throw damage has occurred within this area. This is a result of wet soil, shallow root systems, and exposed location. Before destruction the canopy consisted of black, red, white, and swamp white oak (*Quercus bicolor*), white ash, red maple, and black gum (*Nyssa sylvatica*).

The shrub stratum in the spicebush-arrowwood type is 7 to 8 feet high and is continuous and dense. The number of species encountered is greater in this type than in any of the others. Several species of *Rubus*, greenbrier (*Smilax rotundifolia*), and numerous saplings of the various tree species common to the site are locally important.

Herbs are abundant along the stream and the adjoining areas in the few places where the shrubs are sparse. Skunk-cabbage (*Symplocarpus foetidus*), spotted touch-me-not (*Impatiens capensis*), and clearweed (*Pilea pumila*) are the characteristic herbs encountered. The moss layer is better developed in this type than other areas of the forest as a result of the higher percentage of wind-throws which create a more favorable substratum for mosses.

2. Arrowwood-Greenbrier (*Viburnum dentatum-Smilax rotundifolia*) Type.

The arrowwood-greenbrier area occupies 7 per cent of the forest. This type is encountered in two distinct sections of the forest. One is located in a portion that has never been cleared (Fig. 1, at the western edge of the main forest tract). This will be referred to as type no. 1. The second such area is located at the western end of the western part of the forest and will be referred to as type no. 2. The western part of type no. 2 was cleared in 1872 and cultivated until 1890. The part that was farmed has better drainage than the other areas occupied by this type.

The canopy over the arrowwood-greenbrier area is comprised largely of pin oak (*Quercus palustris*), white ash, and red maple. American elm (*Ulmus americana*) occurs in site no. 1, swamp white oak in no. 2, and black gum is present in small amounts in both. The drier portion of the area supports white, red, and black oaks as the principal canopy trees. The canopy there is more open and is about 10 feet lower than in the area which was not cleared.

The shrub stratum is well developed in type no. 1 and in the portion of type no. 2 which was not farmed. In these areas greenbrier has grown onto the other shrubs and saplings present to the extent that it forms an almost continuous layer. There are, however, areas where arrowwood is the principal shrub and other places where it and greenbrier are equally important. The shrub layer in the segment which was farmed is not as well developed but rather is more discontinuous. Locally either greenbrier or arrowwood or both are important, but more often there is no shrub layer at all.

Except in spots, the herb layer is relatively sparse and open. Spring beauty, rue-anemone, spotted touch-me-not, and wood rush (*Luzula campestris*) are the principal herbs in the older woods, whereas *Carex pensylvancia* is more important in the area that had been cultivated. Mosses are of infrequent occurrence.

3. Swamp Fetterbush (*Leucothoe racemosa*) Type.

The swamp fetterbush type occupies 0.5 per cent of the woods. It is situated on the area that was cleared in 1872 and farmed until 1890.

Pin oak is the dominant canopy tree with red maple, swamp white oak, and black gum as associates. These form a more or less continuous canopy that is about 85 feet high.

The shrub stratum is 4 to 5 feet high and is moderately dense and continuous.

Swamp fetterbush is the characteristic shrub, but highbush blueberry (*Vaccinium corymbosum*), greenbrier, and arrowwood are important. Herbs and mosses are sparse.

4. Poison Ivy (*Rhus radicans*) Type

The poison ivy type is the smallest recognized shrub type present in the forest, but it is extremely distinctive. The drainage is very poor. Several inches of standing water are generally present during the winter and early spring.

Stratification consists of only three definable layers—canopy, shrub, and herb. The canopy and herb strata are essentially the same as in the surrounding arrowwood-greenbrier area. The shrub stratum consists primarily of single unbranched stems of poison ivy that originate from an underground system.

Poison ivy is important along the entire fringe of the woods.

C. Tree Reproduction

A description of the vegetation of Hutcheson Forest would be incomplete without a note concerning the distribution of seedlings and saplings of the canopy species. Even though oak and hickory comprise over 85 per cent of the canopy, saplings of these species are seldom encountered. Seedlings are frequent but only a very small percentage remains alive long enough, except in wind-throw openings, to become trees. Of the few saplings of oak and hickory encountered, at least 95 per cent are associated with wind-throw areas.

Of the other canopy species such as white ash, beech, sugar maple, red maple, and Norway maple, all except beech are prolific seeders in the woods. They are all far better represented in the reproductive classes than the oaks and hickories, a situation which is the reverse of the proportional contribution of mature trees in the canopy.

White ash and red maple, while common as seedlings and saplings in the shaded areas, rarely are encountered as trees whose crowns have reached above the understory. But like the oaks and hickories they grow very well in openings created by wind-throws, where they are abundant.

Saplings of sugar maple and Norway maple are common but are not of as frequent occurrence as white ash and red maple, but the number of these is high in proportion to the number of seed trees. Also, their successful seedlings and saplings are not restricted to wind-throw areas but also grow well in places having a continuous canopy and understory.

D. Communities Adjoining the Forest

1. Young Woodlot.

The young woodlot community occupies a poorly-drained area (7 acres) that was utilized as a pasture until 1921, at which time it was abandoned. Approximately half of this area is dominated by American elm, red maple, pin oak, swamp white oak, and white ash which average about 25 feet in height. The other half is dominated by river birch (*Betula nigra*) of equal height. The shrub layer is ill-defined except locally where greenbrier or poison ivy are important. *Poa trivialis* is the principal herb, and it occurs with lesser amounts of species common in old fields.

2. and 3. Lowland Thicket and Marsh.

These communities are located on a site formerly occupied by a small pond that was drained in 1935. The portion which corresponds to the shallower part of the pond is covered with a thicket of silky dogwood (*Cornus amomum*), and small trees of red maple and pin oak. *Carex* spp., *Juncus* spp., *Polygonum* spp., sensitive fern (*Onoclea sensibilis*), and skunk-cabbage dominate the herb layer. The marsh occupies a section which corresponds to the deeper portion of the pond. It is dominated by the same herbs present in the thicket. Common elder (*Sambucus canadensis*) occurs in isolated clumps as the only major woody species.

4. Old Field.

The section mapped as old field occupies 8 acres. It was abandoned agriculturally in 1921. Pin oak trees scattered liberally throughout dominate the aspect, but among them there is a mosaic of open grassy spaces and individuals and clumps of shrubs and

trees. Clumps of bayberry (*Myrica pensylvanica*), river birch, Japanese honey-suckle (*Lonicera japonica*), red cedar (*Juniperus virginiana*), and hawthorn (*Crataegus* sp.) are important locally. Between the clumps *Andropogon scoparius, Potentilla simplex,* and numerous other characteristic old field species exist in abundance. *Polytrichum ohioense* (Ren. & Card.) is frequently encountered between the clumps of herbs.

5. Fields 1–7.

Fields 1 and 2 were planted in 1954 in corn with Italian rye-grass (*Lolium multiflorum*) as a cover crop. In 1955 they were planted in oats with a mixture of white and yellow sweet clover (*Melilotus alba* and *M. officinalis*). In 1956 these fields are dominated by Italian rye-grass, white and yellow sweet clover, and alsike clover (*Trifolium hybridum*).

Field 3 was abandoned agriculturally in 1950. *Potentilla simplex, Aster* sp., *Solidago* sp., *Juncus effusus, Linaria vulgaris, Plantago lanceolata,* and *Agrostis alba* dominate the aspect.

Fields 4, 5, and 6, in 1956, are planted in soybeans, corn, and wheat respectively. Field 7 is being used as a playground by East Millstone School.

IV. Discussion

Several investigators have employed certain dominant species of the lower layers of the community in conjunction with dominant canopy species as a criterion for classifying associations or as a basis for quantitative sampling. Daubenmire (1952), in a study of the coniferous forest of northern Idaho and adjacent Washington north and east of Columbia Plateau, recognized four vegetation zones (*Picea engelmanni-Abies lasiocarpa, Thuja plicata-Tsuga heterophylla, Pseudotsuga taxifolia* var. *glauca,* and *Pinus ponderosa*). With the aid of dominants of the lower strata he classified these four vegetation zones into 13 climax plant associations. Oosting and Billings (1939) and Oosting and Bourdeau (1955) in phytosociological studies of two different virgin hemlock forests in western North Carolina were able to distinguish two distinct hemlock communities on the basis of associated species of the lower strata. McCormick (1955) found it profitable to use shrub distribution as a criterion to recognize certain communities in the New Jersey Pine Barren region.

The shrub layer of the Hutcheson Forest is so distinctive from place to place that it has been used as an indicator of communities in the area. The term shrub type is used to designate these various forest communities. The shrub layer is not considered as a community in the sense of Lippmaa (1939) but as an integral part of the forest unit of which it is the indicator.

In some of the shrub types there are no detectable changes taking place in relative dominance within the lower layers of the forest. This is not true of the canopy species, and in the course of time the influence of canopy changes may have their effect on the inferior strata.

The eight shrub types in the Hutcheson Forest vary considerably in their characteristics. They fall into three groups: (1) In some of them, a few dominants with the ability to carry through their complete life cycle have become established and little or no change is taking place in the composition. (2) In others the dominants are able to reproduce and maintain themselves vegetatively, rarely if ever carrying through all stages of their life cycle. (3) In still others no species have as yet gained dominance, the shrub layer being an unorganized mixture of species.

In the first of these groups are four shrub types: the maple-leaved viburnum type, the arrowwood-greenbrier type, the spicebush-arrowwood type, and the black-haw type. The first three of these might be thought of as being stable in respect to all but the canopy layer, since the latter is the only layer that exhibits any detectable change taking place. Of these, maple-leaved viburnum is the type occurring on well-drained sites. Maple-leaved viburnum is the dominant shrub in mature forests of well-drained areas of the New Jersey Piedmont. In Bard's (1952) work on old field succession she first encountered this species in a 60-year-old field where it was secondary in importance, but she found it to be the dominant shrub in the mature forest. The spicebush-arrowwood

and the arrowwood-greenbrier types are both typical of sites having higher moisture levels. The spicebush is a particularly widespread indicator of moist soils, occurring even under flood plain conditions (Buell and Wistendahl, 1955; Wistendahl, 1955). With the exception of the canopy species, the members of these types seem to be living in complete harmony with the environment of the forest. The presence of the other types is attributable to historical factors or chance dissemination and establishment and they are to be considered as successional. The black-haw type owes its existence to more open conditions. As shading becomes more intense, black-haw is less vigorous and fails to flower. Maple-leaved viburnum is encroaching on the more shaded areas within this shrub type, thus indicating the indeterminate position of black-haw as a dominant in the shrub layer.

In the second group, those shrub types in which the dominant shrub is perpetuated by vegetative reproduction with flowering and fruiting uncommon, are choke-cherry and poison ivy types. The choke-cherry is not common in this part of New Jersey, and even on the margin of the woods where it gets full light intensity it rarely produces seed. Bard (1952) did not mention it as occurring in the old fields that she studied. The poison ivy in contrast is exceedingly common in this part of New Jersey. Bard encountered it in fields of all ages as well as in the mature forest, but it was most abundant in fields from 25 to 60 years of age. Its local dominance in the woods is related to a peculiar drainage situation.

The third group includes shrub types that occupy most of the area that was cultivated in the late 1800's. Black cherry characterizes one type and swamp fetterbush the other, but in each instance there are a number of associated species. The black cherry of the former type is not a shrub, of course, even though it is occupying a position with the shrubs. It appears to be existing in a suppressed state in which there is a constant replacement of older individuals by younger, more vigorous basal sprouts. There has not been sufficient time since abandonment for the canopy and understory to become continuous. Consequently, black cherry has been able to persist in a suppressed state without being eliminated. This community is bound to change through the deterioration of the cherry. There is no indication in the woods that this species has ever been successful as a forest tree. In this part of New Jersey it is primarily a small tree of open places. Bard found it ubiquitous in fields although never in large numbers.

In that designated the swamp fetterbush type, no species is predominant, there being a considerable mixture of species. Although arrowwood is most important, the swamp fetterbush is second and gives the type its distinction. Like the black cherry type, it appears to be undergoing successional development from the recent period of cultivation.

The values of using shrubs as indicators in a forest such as Hutcheson Forest are several. First, the shrubs are more sensitive than trees to variations within the habitat. Secondly, they are more useful than herbs, particularly since they are conspicuous and recognizable at all seasons.

The usefulness of shrubs in classifying associations as Daubenmire (1952) has done is restricted to climax or near climax communities. In vegetational studies, at least of late successional stages, they can be used as under circumstances similar to the Hutcheson Forest, in recognizing units for mapping or for related field work.

V. Summary

1. An oak stand on the New Jersey Piedmont was mapped with shrubs as indicators. Eight shrub types, four each on well-drained and poorly-drained sites, were recognized. These were divisible into relatively stable and successional units with maple-leaved viburnum the established shrub on well-drained sites and combinations of spicebush, arrowwood, and greenbrier on poorly-drained areas.

2. In this woods, shrubs are more useful in mapping than are trees or herbs. The trees apparently are not sensitive enough to express slight but significant changes in local environments. Herbs express these changes but are more discontinuous in distribution than the shrubs and are not eveident during all seasons.

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(Continued from Bull. Torrey Club 84: 126–134, 1957.)

J. HARRY LEHR

LEGUMINOSAE

CASSIA

*CASSIA NICTITANS L. Partridge Pea. Ramapo. (H)

BAPTISIA

*BAPTISIA TINCTORIA (L.) R. Br. Wild Indigo. Ramapo. (H)

CROTALARIA

CROTALARIA SAGITTALIS L. Rattlebox. Ramapo. (H)

CYTISUS

*CYTISUS SCOPARIUS (L.) Link. Scotch Broom. Ramapo. (H)

Trifolium

Trifolium agrarium L. Yellow Clover. General.
T. arvense L. Rabbit-Foot Clover. Ramapo. (H)
T. hybridum L. Alsike Clover. General.
T. pratense L. Red Clover. General.
*T. procumbens L. Low Hop-Clover. Ramapo.
T. repens L. White Clover. General.

Melilotus

Melilotus alba Desr. White Sweet Clover. General.
M. officinalis (L.) Lam. Yellow Sweet Clover. General.

Medicago

Medicago lupulina L. Black Medic. General.
M. sativa L. Alfalfa. General.

Amorpha

*Amorpha fruticosa L. Indigo-Bush. Haverstraw. A single station on the banks of the Hudson River.

Tephrosia

Tephrosia virginiana (L.) Pers. Goat's Rue. Haverstraw, Stony Point.

Robinia

Robinia hispida L. Rose-Acacia. Ramapo. (H)
R. Pseudo-Acacia L. Black Locust. General. (H)

Desmodium

Desmodium canadense (L.) DC. Tick Trefoil. Ramapo. (H)
D. nudiflorum (L.) DC. Naked-flowered Tick Trefoil. Ramapo. (H)
D. paniculatum (L.) DC. Panicled Tick Trefoil. Ramapo. (H)
D. rotundifolium DC. Prostrate Tick Trefoil. Ramapo. (H)

Lespedeza

Lespedeza capitata Michx. var. vulgaris T. & G. Roundheaded Bush Clover. Ramapo.
L. hirta (L.) Hornem. Hairy Bush Clover. General.
L. intermedia (S. Wats.) Britt. Wand-like Bush Clover. Ramapo.

Vicia

Vicia Cracca L. Wild Vetch. Clarkestown.
V. tetrasperma (L.) Moench. Slender Vetch. Ramapo. (H)

Apios

Apios americana Medic. Ground Nut. Clarkestown.

Strophostyles

Strophostyles helvola (L.) Ell. Wild Bean. Haverstraw. (H)

Amphicarpa

Amphicarpa bracteata (L.) Fern. Hog Peanut. Ramapo, Clarkestown.

OXALIDACEAE

Oxalis

Oxalis europaea Jord. Yellow Wood-Sorrel. General. (H)
O. stricta L. Upright Yellow Wood-Sorrel. General. (H)

GERANIACEAE

GERANIUM

GERANIUM CAROLINIANUM L. Carolina Crane's-Bill. Clarkestown. (H)
G. MACULATUM L. Wild Crane's-Bill. General. (H)
G. ROBERTIANUM L. Herb-Robert. Orangetown. Flowers from May until the first week in December; the county's latest flowering native plant. (H)
G. SIBIRICUM L. Siberian Crane's-Bill. Ramapo, Haverstraw. (H)

RUTACEAE

XANTHOXYLUM

XANTHOXYLUM AMERICANUM Mill. Common Prickly-Ash. A single station and one of the southernmost ones in New York State. Stony Point. (H)

PTELEA

*PTELEA TRIFOLIATA L. Common Hoptree. A single specimen growing on the edge of a swamp beside a railroad track. Stony Point. (H)

SIMAROUBACEAE

AILANTHUS

AILANTHUS ALTISSIMA (Mill.) Swingle. Ailanthus. General. (H)

POLYGALACEAE

POLYGALA

POLYGALA PAUCIFOLIA Willd. Fringed Milkwort. Ramapo. (H)
P. SANGUINEA L. Nuttall's Milkwort. Clarkestown. A single station which has been destroyed since its first report. (H)
P. VERTICILLATA L. Whorled Milkwort. Ramapo, Clarkestown, Stony Point. (H)

EUPHORBIACEAE

ACALYPHA

ACALYPHA RHOMBOIDEA Raf. Rhombic Three-seeded Mercury. Clarkestown. (H)
A. VIRGINICA L. Three-seeded Mercury. Orangetown. (H)

EUPHORBIA

EUPHORBIA CYPARISSIAS L. Cypress Spurge. Ramapo. (H)
E. ESULA L. Leafy Spurge. Ramapo. (H)
E. MACULATA L. Purslane. Stony Point. (H)
E. VERMICULATA Raf. Hairy Spurge. Stony Point. (H)

ANACARDIACEAE

RHUS

RHUS COPALLINA L. var. LATIFOLIA Engler. Shining Sumac. Ramapo, Haverstraw. (H)
R. GLABRA L. Smooth Sumac. General. (H)
R. RADICANS L. Poison Ivy. General. (H)
R. TYPHINA L. Staghorn Sumac. General. (H)
R. VERNIX L. Poison Sumac. General. (H)

AQUIFOLIACEAE

ILEX

ILEX VERTICILLATA (L.) Gray. Common Winterberry. Ramapo, Clarkestown.

CELASTRACEAE

Euonymus

*Euonymus atropurpureus Jacq. Eastern Wahoo. Persisting after cultivation. Ramapo. (H)

Celastrus

Celastrus scandens L. Climbing Bittersweet. Ramapo, Clarkestown. (H)

STAPHYLEACEAE

Staphylea

Staphylea trifolia L. American Bladdernut. Ramapo, Clarkestown, Orangetown. (H)

ACERACEAE

Acer

Acer pensylvanicum L. Striped Maple. Clarkestown, Haverstraw.
*A. platanoides L. Norway Maple. Ramapo.
*A. Pseudo-Platanus L. Sycamore Maple. Haverstraw.
A. rubrum L. Red Maple. General. (H)
*A. saccharinum L. Silver Maple. Orangetown.
A. saccharum Marsh. Sugar Maple. General.

HIPPOCASTANACEAE

Aesculus

*Aesculus Hippocastanum L. Horsechestnut. Ramapo.

BALSAMINACEAE

Impatiens

Impatiens capensis Meerb. Jewelweed. General. (H)
*I. capensis Meerb. forma *albiflora* (Rand & Redf.) Fern. & Schub. White-flowered Jewelweed. Stony Point. (H)
*I. pallida Nutt. Pale Jewelweed. Clarkestown, Haverstraw. (H)

RHAMNACEAE

Ceanothus

*Ceanothus americanus L. New Jersey Tea. Ramapo, Clarkestown. (H)

VITACEAE

Parthenocissus

Parthenocissus quinquefolia (L.) Planch. Virginia Creeper. General.

Vitis

Vitis aestivalis Michx. Summer Grape. General.
V. Labrusca L. Fox Grape. General.
V. riparia Michx. River Grape. Stony Point. (H)

TILIACEAE

Tilia

Tilia americana L. American Basswood. General. (H)

MALVACEAE

Malva

Malva neglecta Wallr. Round-leaved Mallow. General. (H)

HIBISCUS

HIBISCUS PALUSTRIS L. Swamp Rose-Mallow. Orangetown, Stony Point. (H)
*H. SYRIACUS L. Shrub-Althea. Orangetown. (H)

GUTTIFERAE

HYPERICUM

HYPERICUM GENTIANOIDES (L.) BSP. Orange-Grass. Ramapo. (H)
H. MUTILUM L. Dwarf St. John's-Wort. Clarkestown.
H. PERFORATUM L. St. John's-Wort. Clarkestown.
H. PUNCTATUM Lam. Spotted St. John's-Wort. Ramapo, Clarkestown.
H. VIRGINICUM L. Marsh St. John's-Wort. Haverstraw. (H)

CISTACEAE

LECHEA

LECHEA ssp. The author has not completed his study and collections of this taxa.

VIOLACEAE

VIOLA

VIOLA BLANDA Willd. Sweet White Violet. Clarkestown, Orangetown. (H)
V. CONSPERSA Reichenb. American Dog-Violet. Ramapo. (H)
*V. CUCULLATA Ait. Marsh Blue Violet. Ramapo. (H)
V. FIMBRIATULA Sm. Ovate-leaved Violet. Clarkestown. (H)
*V. PALLENS (Banks) Brainerd. Northern White Violet. Ramapo, Haverstraw, Orangetown. (H)
V. PALMATA L. Palmate Violet. Orangetown. (H)
V. PAPILIONACEAE Pursh. Common Violet. General. (H)
*V. PAPILIONACEAE Pursh forma ALBIFLORA Grover. Confederate Violet. Stony Point. (H)
V. PENSYLVANICA Michx. var. LEIOCARPA (Fern. & Wieg.) Fern. Smooth Yellow Violet. Ramapo. (H)
*V. PUBESCENS Ait. var. PECKII House. Downy Yellow Violet. Ramapo. (H)
V. ROTUNDIFOLIA Michx. Round-leaved Violet. Ramapo. (H)
*V. SAGITTATA Ait. Arrow-leaved Violet. Stony Point. (H)
V. SORORIA Willd. Sister Violet. Orangetown. (H)
*V. STRIATA Ait. Cream-Violet. A single station for a rarity. Clarkstown. (H)
V. TRILOBA Schwein. Three-lobed Violet. Clarkestown. (H)

CACTACEAE

OPUNTIA

OPUNTIA HUMIFUSA Raf. Eastern Prickly Pear. Rapidly disappearing except at one station where its inaccessibility virtually assures its permanence. Clarkestown, Stony Point. (H)

THYMELAEACEAE

DIRCA

DIRCA PALOSTRIS L. Leatherwood. Probably, at present, the southernmost station in New York State. Clarkestown. (H)

LYTHRACEAE

DECODON

DECODON VERTICILLATUS (L.) Ell. Swamp-Loosestrife. Haverstraw. (H)

LYTHRUM

LYTHRUM SALICARIA L. Purple Loosestrife. Ramapo, Haverstraw. (H)

NYSSACEAE

Nyssa

*Nyssa sylvatica Marsh. Black Tupelo. Haverstraw. (H)

ONAGRACEAE

Ludwigia

*Ludwigia palustris (L.) Ell. var. americana (DC) Fern. & Grisc. Water-Purslane. Ramapo, Haverstraw. H)

Epilobium

*Epilobium angustifolium L. Fireweed. Haverstraw. (H)
E. coloratum Bichler. Purple-veined Willow-herb. Clarkestown, Ramapo.
E. glandulosum Lehm. var. adenocaulon (Haussk.) Fern. Northern Willow-herb. Ramapo. (H)
E. hirsutum L. Hairy Willow-herb. Clarkestown, Ramapo. (H)

Oenothera

Oenothera biennis L. Evening Primrose. General. (H)
O. fruticosa L. var. linearis (Michx.) S. Wats. Long-stemmed Sundrops. Ramapo, Clarkestown. (H)
O. parviflora L. Northern Evening Primrose. Ramapo. (H)
O. perennis L. Small Sundrops. Ramapo. (H)

Circaea

Circaea quadrisulcata (Maxim.) Franch. & Sav. var. canadensis (L.) Hara. Enchanter's Nightshade. Ramapo. (H)

HALORAGACEAE

Proserpinaca

*Proserpinaca palustris L. Mermaid-Weed. Ramapo, Clarkestown. (H)

ARALIACEAE

Aralia

*Aralia hispida Vent. Bristly Sarsaparilla. Ramapo. (H)
A. nudicaulis L. Wild Sarsaparilla. General. (H)
A. racemosa L. Spikenard. Orangetown. (H)

Panax

Panax quinquefolius L. Ginseng. A single station for this rarity but its future is uncertain for it grows beside one of the Palisades Interstate Park trails. Ramapo. (H)
P. trifolius L. Dwarf Ginseng. Ramapo. (H)

Hedera

*Hedera Helix L. English Ivy. Persisting after cultivation. Haverstraw. (H)

UMBELLIFEREAE

Hydrocotyle

Hydrocotyle americana L. American Marsh Pennywort. Ramapo. (H)

Sanicula

Sanicula marilandica L. Black Snakeroot. Stony Point. (H)

OSMORHIZA

OSMORHIZA CLAYTONI (Michx.) C. B. Clarke. Sweet Cicely. Ramapo, Stony Point. (H)
O. LONGISTYLUS (Torr.) DC. Anise-Root. Ramapo, Clarkestown. (H)

ZIZIA

*ZIZIA APTERA (Gray) Fern. Heart-leaved Golden Alexanders. Clarkestown. (H)
Z. AUREA (L.) W. D. J. Koch. Golden Alexanders. Ramapo, Clarkestown. (H)

CICUTA

*CICUTA BULBIFERA L. Bulb-bearing Water Hemlock. Ramapo, Clarkestown. (H)
C. MACULATA L. Water Hemlock. General. (H)

CRYPTOTAENIA

CRYPTOTAENIA CANADENSIS (L.) DC. Honewort. Ramapo. (H)

PIMPINELLA

*PIMPINELLA SAXIFRAGA L. Burnet-Saxifrage. An infrequent adventive from Europe, fully naturalized at this station but its future is uncertain because of the area's proximity to a new residential development. Ramapo. (H)

SIUM

SIUM SUAVE Walt. Water Parsnip. Orangetown, Stony Point. (H)

ANGELICA

ANGELICA ATROPURPUREA L. Great Angelica. Ramapo, Stony Point.
*A. VENENOSA (Greenway) Fern. Hairy Angelica. Haverstraw. (H)

PASTINACA

PASTINACA SATIVA L. Wild Parsnip. General. (H)

DAUCUS

DAUCUS CAROTA L. Wild Carrot. General. (H)
D. CAROTA L. forma EPURPURATUS Farw. Ramapo. (H)

CORNACEAE

CORNUS

*CORNUS AMOMUM Mill. Silky Cornel. Ramapo, Stony Point. (H)
C. FLORIDA L. Flowering Dogwood. General. (H)
*C. RACEMOSA Lam. Racemose Dogwood. General. (H)
C. RUGOSA Lam. Round-leaved Dogwood. Orangetown.
C. STOLONIFERA Michx. Red-Osier Dogwood. Ramapo. (H)

CLETHRACEAE

CLETHRA

CLETHRA ALNIFOLIA L. Sweet Pepperbush. General. (H)

PYROLACEAE

CHIMAPHILA

CHIMAPHILA MACULATA (L.) Pursh. Spotted Wintergreen. General. (H)
*C. UMBELLATA (L.) Bart. var. CISATLANTICA Blake. Pipsissewa. Haverstraw. (H)

PYROLA

PYROLA ELLIPTICA Nutt. Shinleaf. Ramapo. (H)
*P. ROTUNDIFOLIA L. var. AMERICANA (Sweet) Fern. Round-leaved Pyrola. Clarkestown. (H)

MONOTROPA

MONOTROPA UNIFLORA L. Indian Pipe. General. (H)
(To be continued)

PROCEEDINGS OF THE CLUB

December 18, 1956. The meeting, at Columbia University, was called to order by President Barton at 8:00 P.M. There were 38 members and guests present.

The minutes of the previous meeting were approved as read.

Mr. Paul P. Bedesem Jr. and Mr. Carl Monk were elected to Active (annual) Membership by the Club.

Dr. Barton called upon Dr. Taylor, Chairman of the Nominating Committee (Hollinghurst, Fairbrothers, and Cheney), to give a report on the slate of officers chosen for 1957. The following persons were nominated:

President	Edwin T. Moul Harold W. Rickett
Vice-President	Donald D. Rogers
Corresponding Secretary	Peter K. Nelson
Recording Secretary	Frank G. Lier
Treasurer	
Editor	Charles A. Berger
Manager of Publications	
Bibliographer	Lazella Schwarten
Representative on the Board of Managers of The New York Botanical Garden	P. W. Zimmerman
Representatives on the Council of the A.A.A.S.	A. E. Hitchcock Lindsay S. Olive
Council Members 1957–1959	Murray F. Buell Annette Hervey Edwin B. Matzke Eleanor Witkus

The following nominations for Council Members were then made from the floor:

Dr. Jennie L. S. Simpson —Nominated by Dr. Lawton
Dr. Harold A. Clum —Nominated by Dr. Rickett

Dr. McNew then moved that nominations be closed. The motion was seconded and approved by the Club.

This was followed by several announcements.

Dr. Clum was called upon to announce some details for the Dinner for Botanists at the A.A.A.S. Meetings. The Dinner will be held on Thursday, December 27, at the Statler Hotel. Reservations must be made by noon on the 27th.

Dr. Barton then announced that the Torrey Botanical Club would be in charge of the Empire Room of the Statler which would serve as a headquarters for botanists at the meetings.

The Annual Meeting and Dinner of the Torrey Botanical Club will be held on January 15, 1957 at the Men's Faculty Club of Columbia University. Dr. Maxwell Doty of Hawaii will speak at the meeting on "The Botanical Nature of Coral Atolls".

The scientific program of the evening consisted of a talk by Dr. John T. Bonner of Princeton University on, "Recent Studies on Differentiation in Slime Molds". Dr. Bonner's abstract follows:

> A basic problem in the study of the development of slime molds is an explanation of their proportional development. Certain cells become stalk cells and others become spores, and the proportion of these two groups remains constant whether the cell mass is small or large. By comparing the histochemical changes of these tissues during the development of different species and by making quantitative comparisons of their proportions, it is possible to gain some insight into possible mechanisms that

might be involved. Furthermore, this information provides a useful basis for speculation on the evolution of the cellular slime molds.

After a discussion period the meeting was adjourned at 9:30 P. M.

Respectfully submitted
Frank G. Lier
Recording Secretary

Annual Meeting of January 15, 1957. After a dinner served at the Men's Faculty Club, Columbia University, President Barton introduced the speaker of the evening, Dr. Maxwell S. Doty of the University of Hawaii, who addressed the Club on, "Coral Atolls, Their Botanical Nature". The theme of Dr. Doty's talk was that the major building of an active reef is done by red algae at the outermost fringe of the reef, and not by coral polyps as is generally believed. His talk was illustrated with Kodachrome slides of Pacific Atolls.

President Barton then called the Annual Meeting to order at 8:35 P.M. Eighty-four members and guests were present.

The minutes of the meeting of December 18, 1956 were read and approved.

The following were elected to Active (annual) Membership by the Club: Mr. Herman F. Becker, Dr. Florence Fitzpatrick, Brother Bernardine Julian, F. S. C., Mr. Conrad F. Meyer, and Dr. Hans H. Zinsser. Mr. R. R. Anderson and Mrs. Dorothy Kolber were elected to Associate Membership.

The following resignations were announced with regret: Prof. H. Bormann, Mr. Charles B. Heiser, Mr. Richard Pough, Dr. Harold St. John, and Dr. Richard Starr, Active Members and Mrs. Louis Hand, Associate Member.

Dr. Barton then called for the Annual Reports from the Officers of the Club and Chairmen of the Standing Committees.

The Chairman of the Field Committee, Mr. Fairbrothers and the Chairman of the Local Flora Committee, Mr. Lehr, gave reports which are appended to these minutes.

The report of the Business Manager, Dr. Duffy was read by the Recording Secretary. Dr. Zimmerman, Representative on the Board of Managers, New York Botanical Garden then gave his report. Both of these reports are appended.

Dr. Keck reported on the Club's participation in the New York meetings of the A.A.A.S. He stated that the exhibits set up in the Empire Room of the Statler Hotel were well attended. These included an exhibit of fern spores by Miss Hires of the Mistaire Laboratories, Tritium labeled chromosomes by Dr. Taylor of Columbia University, and an exhibit of material on Island Beach Park by Rutgers University.

Dr. Bard announced that the final Treasurer's report could not be made since the bills for the final 1956 issue of the Bulletin had not been received.

Dr. Barton then asked Dr. Hervey, Chairman of the Budget Committee, to explain the proposed budget for 1957. After her report was given, Dr. Small proposed the motion, seconded by Mr. Lehr, that the budget be accepted as read. The motion was passed by a unanimous vote. A copy of the budget is appended.

The President, Dr. Barton, then gave her final report to the Members. This is also made a part of these minutes. She explained that it would not be possible to announce the results of the election of officers for 1957 until the next meeting of the Club on February 7, 1957.

Dr. Small suggested that the adjournment of the Annual Meeting be postponed until next time so that the announcement of the elections could be made a part of the business of the Annual Meeting. No action was taken on this proposal.

Dr. Keck suggested that the members give the President a vote of thanks for her service to the Club during the past year. This was done.

The meeting was adjourned at 9:15 P.M.

Respectfully submitted
Frank G. Lier
Recording Secretary

February 5, 1957. The meeting, at Columbia University, was called to order by Dr. Barton at 8:00 P.M. There were 65 members and guests present.

The minutes of the previous meeting were approved as read.

Dr. Barton called upon Dr. Taylor, Chairman of the Nominating Committee, to give the results of the election. The new officers for 1957 are as follows:

President—Harold W. Rickett, New York Botanical Garden.
Vice-President—Donald P. Rogers, New York Botanical Garden.
Corresponding Secretary—Peter K. Nelson, Brooklyn Botanic Garden.
Recording Secretary—Frank G. Lier, Columbia University.
Treasurer—Rita McMahon, Fordham University
Editor—Charles A. Berger, Fordham University.
Manager of Publications—Jack McCormick, American Museum of Natural History.
Bibliographer—Lazella Schwarten.
Chairman of the Field Committee—David E. Fairbrothers, Rutgers University.
Chairman of the Local Flora Committee—J. Harry Lehr, Spring Valley, New York.
Representative on the Board of Managers, The New York Botanical Garden—P. W. Zimmerman, Boyce Thompson Institute for Plant Research.
Representatives on the Council of the A.A.A.S.—A. E. Hitchcock, Boyce Thompson Institute for Plant Research. Lindsay S. Olive, Columbia University.

Members of the Council 1957–1959

Murray F. Buell, Rutgers University.
Harold H. Clum, Hunter College.
Annette Hervey, New York Botanical Garden.
Edwin B. Matzke, Columbia University.

Dr. Barton introduced Dr. Rickett, the President for 1957 who took over the chair for the remainder of the meeting.

Mr. James R. Nolan was elected to Active (annual) Membership in the Club.

Dr. Rickett introduced the speaker of the evening, Dr. Lindsay S. Olive of Columbia University, who spoke on, "Tahiti: Its People, Plants, and Customs".

Dr. Olive showed examples of the handicrafts of the people of Tahiti and surrounding islands. Among these were samples of tapa cloth, "grass" skirts made from the bark of a tree species of Hibiscus, and a carved wooden idol or Tiki. The remainder of Dr. Olive's talk was illustrated with handsome colored slides that showed the people, plants, and customs in a most fascinating manner.

After a period of discussion, the meeting was adjourned at 9:00 P.M.

Respectfully submitted
Frank G. Lier
Recording Secretary

Notes

The Torrey Botanical Club acted as host to all botanists attending the A.A.A.S. meetings, December 26 to 29th, 1956. The two Empire rooms of the Hotel Statler, New York, were provided by the A.A.A.S. for their use. These two comfortable rooms with large mirrors housed three exhibits. Exhibited were "Vegetation Map of Island Beach, N.J." by William E. Martin of Rutgers; "Tritium-Labeled Chromosomes" by J. H. Taylor of Columbia; and "Spores in Three Dimensions" by Miss Clara S. Hires of Mistaire Laboratories.

Spores in Three Dimensions

Miss Hires showed and discussed about 300 working models and also photomicrographs of spore tetrads, spores and spore detail. The models were made to clarify 3-dimensional forms and to correct the 2-dimensional picture seen with a microscope. They illustrated numerous angles and focal levels, and explained the effects of linear perspective and shadows. Conventional concepts of spores, as described in past and contemporary literature, were displayed in full; but the bulk of the exhibit was devoted to Miss Hires' own basic spore plan and its variations.

This basic plan, found in fern spores of all species studied at Mistaire, shows the spore to be a tetrahedral quarter-section of a rounded mother-cell. Paired ridges edge the three nearly triangular contact surfaces of the four spores in the tetrad. Each face has two straight inner and one curved outer edge. The straight ridges radiate from the center to form triradiate patterns. These do not end at the surface but curve at the outer spore edge connecting the prongs of each spore. The tetrad surface is thus divided into four curved triangles, each bounded by curved ridges but no circular equator.

Each spore thus formed consists of three principal areas. 1) An outer wall or coat is made up of a series of membranes, in which ridges, tiny markings, and coloration develop as the spore matures. 2) A cytoplasmic bowl-shaped area, more or less triangular and enclosed in a separate wall, contains cytoplasm, nucleus, plastids, and fat globules. 3) A nutritive region, lying between the inner bowl surface and the triradiate ridge, holds clear fluid of a different refractive index from water or cytoplasm.

Variations from this basic plan indicated how spore development after tetrad division affects shape. These were displayed with models of separate parts to be assembled in various combinations.

The exhibit included sectioned tetrad and spore models, made to simulate the effects of microtome sectioning of actual tetrads and spores. Sectioning was done at many angles and demonstrated shape, as well as wall and nuclei arrangements, possible at different focal levels under the microscope.[1] These models showed how certain trilete sections could appear similar to typical monolete. A central section of a trilete tetrad could show the central nutritive areas surrounded by three bean-shaped sections of the cytoplasmic bowls around the outer tetrad. This was also demonstrated with photomicrographs and lantern slides.

In explaining the spore coat, the tendency of ridges to form a hexagonal pattern was illustrated. Bulging, flat and indented areas between the ridges were compared. Some projections from these areas are shaped like hollow electric light bulbs or collar buttons, rising from hexagonal bases, sometimes at alternate levels.

The hexagonal pattern was demonstrated with several materials, such as copper picture wire, to show wall striations. Different types of small projections arise where ridges join but may be effects caused by other ridges curving around the spore edge. Models of details, both sectioned and entire, ranged in magnification from 2,000 to 50,000×.

Each of the many media used has certain limitations to consider, described in "Models for Spore Study,"[2] by Maud Mary Griswold, Miss Hires' former assistant, who made many of the models under her direction.

It is hoped that this demonstration in 3-dimensional form will help convince others of the truth of concepts, such as that of the cytoplasmic bowl, which have been so difficult for some to visualize.—CLARA S. HIRES.

Vegetation Map of Island Beach State Park, New Jersey

A colored map has been prepared showing the vegetation and other natural features of Island Beach which is an offshore sandbar about nine miles long located on the Jersey

[1] "Tetrad Analysis Through Sectioned Models," by Clara S. Hires, *Bulletin of the Torrey Botanical Club*, Vol. 83, No. 1, pp. 72–76, Jan. 1956.

[2] "Models for Spore Study," by Maud Mary Griswold, *American Fern Journal*, Vol. 46, No. 1, pp. 1–6, Jan.–March 1956.

shore between Seaside Park and Barnegat Inlet. This area is unique in that its vegetation cover, thanks to a fortunate chain of circumstances, has been preserved in a nearly natural condition. Island Beach is the only sizable area on the New Jersey coast where natural vegetation of this kind still exists.

Island Beach State Park is not yet open to the public, but plans for its future development provide not only for public recreation areas but also for certain areas to be set aside as nature preserves and wildlife sanctuaries. The problems involved in the use and management of such areas so as to maintain their natural character can neither be anticipated nor adequately dealt with until the significant ecological principles and processes have been elucidated.

The vegetation of the bar consists of a variety of plant communities which fall into a complex pattern of distribution as shown by the above mentioned map. Preliminary studies, on which the map is based, seem to indicate that these complex patterns may be resolved to orderliness by an explanation based on the sorting out of species and plant communities along fairly definite environmental gradients. The significant variables of the environment seem to be those related to moisture conditions, windborne salt spray, and the movement and drifting of unstable sand.

Experimental and field studies, now in progress, are designed to determine the relationship between water table and the vegetational pattern, the relative resistance of various species to damage by windborne salt spray, and the influence of sand removal and deposition on dune-building species. The results of these studies may provide the information necessary to explain the patterns illustrated by the map. If the zonation and successional relationships of the various communities can then be explained, a foundation will be established for the management of the area on a sound ecological basis.—WILLIAM E. MARTIN, Botany Department, Rutgers University.

The Organization and Duplication of Chromosomes as Revealed by Autoradiographic Studies using Tritium-Labeled Thymidine

The mechanism of chromosome replication during cell division was demonstrated in an autoradiographic study using tritium-labeled thymidine. Seedlings of *Vicia faba* were grown in a solution containing the thymidine, a precursor of deoxyrbonucleic acid (DNA), for limited periods of time. Plants were then taken from the isotope and grown in a non-radioactive solution containing colchicine. Colchicine treatment permits determination of number of division cycles the chromosomes have gone through following isotope incorporation. At intervals roots were fixed, stained, smeared and placed in contact with autoradiographic film. The autoradiographs showed that the daughter chromosomes resulting from the first replication after incorporation were both equally and uniformly labeled. After an ensuing replication in the absence of the isotope, the label appeared in only one of the two daughter chromosomes.

These findings indicate that (1) DNA is synthesized as a unit which extends throughout the length of the chromosome and which remains intact through subsequent cell divisions, (2) that a chromosome is composed of two such units, probably complementary to each other, and (3) that after each replicates the four resulting units separate so that each daughter chromosome regularly receives an "original" and a "new" unit.—J. H. TAYLOR, P. S. WOODS, and W. L. HUGHES, Department of Botany, Columbia University; Biology Department and Medical Department, Brookhaven National Laboratory.

The proposed budget of the Torrey Botanical Club as adopted at the Annual Meeting on January 15 is presented below since members may wish to know the reason for and the use of the increased dues:

Estimated Income for 1957

Subscriptions and Back Copies of BULLETIN	$3800.00
Membership Dues	3000.00
Advertising in the BULLETIN	275.00
Index cards—Sales	1500.00
Unrestricted Interest from Endowment Funds	850.00
Gift from TAXONOMIC INDEX	100.00
Total Income Expected in 1957	$9525.00

Estimated Expenses for 1957

BULLETIN—Publication	$6800.00
TORREYA—Publication	310.00
Index Cards—Publication	1150.00
Advertisements—Publication	100.00
Office of Treasurer	100.00
Office of Business Manager	125.00
Office of Corresponding Secretary	125.00
Expenses of Meetings	100.00
Office of Recording Secretary	15.00
Office of Editor	60.00
Office of President	15.00
Committee on Increasing Income	25.00
Field Committee	125.00
Nominating Committee	25.00
Bibliographer's Honorarium	150.00
Business Manager's Honorarium	100.00
Treasurer's Honorarium	100.00
Miscellaneous	100.00
Total Expenses Expected in 1957	$9525.00

Respectfully submitted,
Dr. William Crotty
Rev. Joseph E. Schuh, SJ
Dr. Gily Bard, ex officio
Dr. Annette Hervey, Chairman.

BOOK REVIEW

The Palaeobotanist. Volume 4. 157 pages. Published by the Birbal Sahni Institute of Palaeobotany, University Road, Lucknow. 1955. $6.60 postpaid.

This volume contains 20 original papers mostly by the staff members of the Birbal Sahni Institute of Palaeobotany. Five of the papers deal with spores and other microfossils, five with fossil woods, the remainder concern a variety of subjects some being algae from the Salt Range, the *Glossopteris* flora, and plants of the Lower Carboniferous and Deccan Intertrappean series. C. A. A.

BULLETIN OF THE TORREY BOTANICAL CLUB

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INDEX TO AMERICAN BOTANICAL LITERATURE

COMPILED BY

LAZELLA SCHWARTEN

WITH THE COLLABORATION OF THE EDITOR OF BRITTONIA

TAXONOMY, PHYLOGENY AND FLORISTICS

ALGAE

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